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ABSTRACT

The first major section of this report describes in detail an information-integration theory which seeks to explain how an organism selects information and integrates it with other information from the environment and from the organism's internal processes. The model treats information as a pattern of neural activity composed of a plethora of unit data in a matrix of limited processing capacity. In the second major section, the theory is applied to the problems of children having school difficulties. A general model of normal reading acquisition is generated, the problem of short attention span is considered, and other problems in reading are discussed from the perspective of the model. (AA)

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AN INFORMATION-INTEGRATION THEORY AND ITS APPLICATION TO NORMAL READING ACQUISITION AND READING DISABILITY

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The theory is undergoing revision and elaboration. Your comments are invited.

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In order to understand abnormal functioning, it would be useful to have a theory substantiated by experiments which describes the course and functioning of normal behavior. Such a theory together with its supporting factual data would allow us to understand precisely where abnormality is centered. By examining the functioning of the person thought to be disabled in some way we would be able to decipher where his performance varies from that of the normally functioning individual. Such performance differences would imply within the context of the theory processes or systems which are functioning irregularly. These processes or systems would then represent the focus of one's remedial effort.

It should be clear why a theory is necessary in this endeavor and that a collection of unorganized facts will not suffice. Most basically, one need recognize that there are an endless number of data points that one could collect that would discriminate between any two samples of persons. Understanding deviant functioning or any functioning for that matter proceeds not simply by having a large collection of data but by having those data organized into a coherent framework. A framework allows some data to take on more importance in understanding the disability than others by specifying the manner in which the data are related to each other.

Besides the basic function of organizing facts into meaningful relationships, theory is particulary important in understanding deviant functioning. To be recognized as meaningful deviant functioning, behavior need be abnormal in a manner which has profound consequences for the individual and likely also for his family and more broadly for society in general. The deviance, thus, ordinarily involves a large segment of the person's life. As such, the disability creates many differences that are not etiological or otherwise basic to the disability itself. Said most simply, deviance seems to breed deviance such that the individual given an abberrant manner of behaving tends to have this deviance affect many aspects of his life. Consequently, there are an endless number of ways in which the deviant individual differs from a person not so afflicted. The need for a theory is seen in the necessity to organize the atypical behaviors into a coherent, meaningful pattern. Without a theory, the enumeration of deviant behaviors goes on unchecked, resulting in a proliferation of constructs which complicate rather than illuminate our understanding. Without a theory, the constructs are frequently heavily overlapping and as such terribly redundant. Furthermore, the body of constructs has no specified relationships between one another. Hence, the deviant individual is thought to have a multitude of problems where an appropriate theoretical conception may show him to have only one basic problem with performance in other spheres aggravated by this specific deficit.

Recently, the area of learning disabilities, with which this paper is primarily concerned, has gravitated toward constructs familiar to information-processing psychology in lieu of the medical terminology which had not proven educationally meaningful. Terms such as selective attention, visual discrimination, auditory discrimination, visual perception, visual-motor functioning, sound blending, and the like cast the disabled learners' deficits within a psychological perspective. Rather than impute to the child genetic or organic anomalies, the field has chosen, wisely I think, to describe the child's disorder in terms of those underlying processes which limit his ability to utilize language. Though information-processing models represent only one possible approach, their simplicity and intuitive appropriateness for understanding

educational disabilities more than justifies their selection.

The field of special education has encountered problems with the information-processing framework, however, which stem, I believe, from an unwillingness of persons in the field to accept the interpretive restrictions which any specific information-processing model will necessarily contain. Though the information-processing terminology has been accepted, the uniqueness of competing models has been lost and with it the interpretive power and research generating potential. Consequently, the field has fallen prey to the proliferation of terms which results when a theory does not guide one's thinking. There are notable exceptions to this general state of affairs, for example the adoption of an Osgood Linguistic Model which underlies the ITPA, but this is nearly unique in its adherence to a coherent framework.

An analysis of the attentional deficiencies of learning disabled children as is being undertaken here would require that we cast attention in a specific theoretical framework. Despite the work of the last ten years or so in the field of cognitive psychology in constructing models of attention and associated processes, I find no single model satisfactory for understanding the difficulties encountered by learning disabled children. Furthermore, I find the existing models lacking in a number of other respects including their inability to account for certain germane experimental data and their severely restricted conceptualization of the information processing capabilities of the human organism. I am thus offering an alternative model which I will first describe in considerable detail and then use to analyze the information-processing difficulties of learning disabled children.

BACKGROUND TO THE THEORY

Dissatisfactions with Present Information-Processing Models

My dissatisfaction with present information-processing models is in part philosophical: Viewing man as most of these models do as one who decodes sensory inputs, holds them for brief periods of time, stores some for longer term use, and then later retrieves these stored signals does not do justice to the complexity of the information handling abilities of the human being. It is not that I seek more humanistic terms but rather wish to provide a framework within which information-processing research techniques can be utilized to study the organism's broader capabilities.

The most basic problem encountered with existing models is their insensitivity to feedback and under-representation of the organism's active role in information-processing tasks. Information-processing models typically adopt the traditional view that man's behavior (responses) is a function of environmental events (stimuli). More recent conceptions (e.g., Pribram, 1969) have stressed the importance of the organism's internal state as well as its productive capabilities in determining the particular response that will occur. Though it is widely recognized that the state of the organism will affect its dealings with the external world, it has not been easy for psychologists to build this observation into their theories. What we want to conceptualize is the notion that each behavior of the individual becomes part of its surroundings by virtue of various feedback mechanisms. Man hears what he says, feels what he does, and perhaps most importantly, has verbal awareness of his own behavior. These self-perceptions

provide a more continuous cue base from which to generate behavior than that afforded by the external environment. The organism's cue base plus the stimuli impinging on him provide the context for his behavior.

In addition to the general orientation of present information-processing models, I take issue with certain more specific aspects shared by most present conceptualizations. As each of these problems will be discussed in detail below, I shall only refer to them here.

Exclusive reliance on linguistic materials. First, I think many present models generally overlook or underestimate the uniqueness of linguistic stimuli, whether presented visually as graphic symbols or auditorily as spoken speech. In relying almost exclusively on such linguistic stimuli for their experiments, psychologists have generated data and associated models which may be limited in their explanatory power to linguistic materials alone. Not only may they be limited but they may be erroneous to the extent that linguistic material has properties not shared by other kinds of information.

Our notions of attention within an information-processing context is a case in point, deriving in large part from experiments with linguistic materials. The early Cherry (1953) and Broadbent (1954) experiments together with the model derived from this line of investigation (Broadbent, 1957, 1958) led psychological researchers to ask whether attention were unitary, to be deployed totally to a given signal, or divisable, to be shared if necessary between two or more signals. This basic question about attention had distinct implications for the processing of information: Were attention non-divisable, simultaneous reception of two distinct streams of continuous speech would not be possible. A person interested in both speeches going on simultaneously would need to switch his attention back and forth from one speech to the other. By utilizing the redundancies in speech and by carefully timing one's attention to each speech, one could grasp most of the meaning and perhaps have the impression of having listened to the two conversations at the same time. The opposite conceptualization, that attention can be divided between two incoming signals, purports that information can be processed in parallel, that is two streams at the same time. This issue of whether attention is unified or divisible and the associated question of whether information is processed sequentially or in a parallel have occupied the time and energy of psychologists for a number of years. As I shall make clear below I think both of these are pseudo-issues, born out of a conceptualization of information-processing derived from and limited to the study of linguistic material.

Auditory decoding of linguistic material. A second problem with present information-processing models is their assertion that language decoding operates through an auditory-verbal-linguistic process. It is generally held, although recent experiments contradict this notion (Parkinson, 1972), that linguistic stimuli are translated to an auditory code for storage. This is not to say that people sub-vocalize as they read or that they repeat to themselves what the speaker is saying. Rather, it says that the code in which these linguistic events are stored is the same code from which the person generated his own language. There are excellent data supporting the position that linguistic stimuli can and frequently are auditorily coded. A prime example is the research on auditory confusions by Conrad (1964) in which he has shown that errors in recalling visually presented items are more similar in sound to the correct item than in shape. The implication is that the graphemes are auditorily coded such that any intrusion errors that result are more likely to sound rather than look like the correct grapheme.

Of course, demonstrating that visual graphic symbols are frequently and under a variety of conditions auditorily coded does not assure that they always are or can only be auditorily coded. Particularly when one considers that in most psychological experiments the subject is required to recall the items presented to him else the psychologist will have no data, he may be prompted to translate visual items into the auditory code appropriate for their output. There may exist a wide variety of conditions in which a person is not so prompted to translate visual graphic symbols into an auditory representation. One such example might be in reading; the accomplished reader may be able to recognize directly the meaning of a pattern of graphic symbols without first translating those graphic symbols into their auditory representation. As recent research (Parkinson, 1972) has shown that purely visual coding of graphic symbols is possible, a revised information-processing model is required.

Fragmentation. A third problem with present models which a new information-processing theory should correct is the fragmentation of information and the derived experiences that is implied by the unified notion of attention. Were we truly to pay attention to only one thing at a time, our experience and the resulting memories of those events would be terribly barren, uni-dimensional. Models which require one to pay attention to a given signal in order to process it put themselves in the position of being unable to account for the richness of immediate experience. Rather than accepting models which implicitly fractionate experience by requiring that channels of information be dealt with only sequentially by the organism. I think we would do better were we to tackle the issue of how to conceptualize man's tremendous ability to integrate a variety of sensory inputs. By implicitly limiting their purview to verbal stimuli (though many do not recognize this restriction) and by finding that as a result of the study with linguistic stimuli that material normally is processed sequentially, information-processing models falsely escape the issue of how, under normal circumstances, so much information seems to be gathered and stored as a unitary experience. An example may clarify the issue: one's walk through a garden on a spring day is not recalled as a sequence of colors, shapes and movements or the sensation of one's own body but as a total experience, a combination of these many impressions. Certainly it is possible that the combination of these sensory impressions occur sometime after their reception and that, as the present information-processing models imply, their reception was accomplished sequentially. However, this does not meet with our immediate experience. More important though, our present models don't address the issue at all. As will become clear below, I believe that the integration process occurs during the reception of the events rather than after their reception in memory. Regardless of one's conceptualization of this specific issue, we do need a model which can deal with the integration of sensory events into unified experiences and memories such that researchable predictions can be made and evaluated.

In summary, I seek to expound a model of information-processing which will do justice to the complexity of man's information-processing abilities including a recognition of the power he achieves by using the cues of his own behavior (sensory feedback, his own language system, and other internal cues) to provide a cue base from which to register and respond to incoming stimuli. In taking into account man's feedback mechanisms, the model also must deal with the response aspects of the system, namely verbal and motoric behavior. It seems terribly optimistic to have considered as our present models do that the response system has no integral relationship with the information-processing system under study. We know for example that the motor system is extremely important in perceptual

development whether one recognizes this fact from an experimental work of Held (1965) or by the more theoretically-oriented work of Piaget (Flavell, 1963). It is likely and comes under question within the context of the model proposed that there exists intimate relationships between the sensory input and motor output systems. The basic realization that it is the same person involved in the input and output and that because of this fact the same limited capacity which gathers information about the world must act on the world requires that we include the output system in our conceptualization of information-processing. In addition to being sensitive to the feedback systems which man possesses, the proposed model also seeks a resolution of the issue of whether attention is unitary or divisible and the related issue of whether information is processed sequentially or in parallel. The model also addresses itself to the issue of whether visual linguistic stimuli need to be coded auditorily and, further, provides a framework within which to study inter-sensory integration and the integration of sensory input with stored material, i.e., incoming stimuli and "thoughts" and as such provides the rudiments of a model of creative thinking.

The Important Role of Attention

Attention has been one of the most illusive constructs with which psychologists have dealt. Though currently popular, being studied by experimental psychologists and prominent in the thinking of health science practitioners, attention was all but absent from experimental psychology in the second through fifth decades of this century. Perhaps because of its mentalistic flavor and to some extent certainly because of its difficulty in being operationalized, attention was shunned by S-R Psychology and more broadly by those of a behaviorist persuation. With the increased interest in cognitive psychology during the past two decades and with the advances in the psychophysiological measurement of attention (the orienting reflex) (Maltzman & Raskin, 1965; Sokolov, 1960), psychologists have once again tried to deal in a formal manner with attention.

The importance of the function of attention cannot be minimized; if one concedes that one need attend to material in order to receive it, it follows that all of our experience is in part determined by the workings of the attentional mechanism. In a very basic sense, you are what you attend to. It is no wonder that cognitive psychology in its interest in examining how the organism receives, transfers, stores and transmits information has actively wrestled with the construct of attention.

The intermittent use of the concept attention, however, causes one to question whether its inclusion is altogether necessary in one's theory. To what aspect or aspects of behavior does the term attention refer? There are at least five characteristic behaviors which have been described in terms of attention. They are: 1) alertness, 2) selectivity, 3) vigilance, 4) preparatory sets, and 5) attentional deployment. Alertness is generally taken to mean the quantitative component of attention, how "hard is one paying attention." Selectivity refers to the content of attention, to which of all the possible cues does one choose to attend? This aspect of attention can refer either to the receptor orienting acts, that is, the direction one orients one's receptors, or to the selection of information internally from the information presented to the organism, as for example, the selection of a person's face when much more information than the face alone is present on one's retina. Vigilance refers to the persistence of attention for a given content. Set refers to the

preparation for responding, rather than for attending to a specific content. Attention deployment refers to the set of rules which determine what the organism attends to. Does one tend to look more than listen, to look at colors more than shapes, does one look at moving things or hear loud noises above all else and so forth?

It is to be noted that all of these dimensions of attention refer to some aspect of information. Alertness refers to the preparation to receive information, selectivity to the specific information being received, vigilance to the persistence with which given information is processed, set to the preparation for selecting a certain type of information, and attentional deployment to the set of rules which determine what gets processed. Is it possible that the term attention is superfluous?

Dropping attentional terminology. Can we omit the word attention and redistribute to various aspects of an information-processing system the functions subsumed under the term attention? I propose that the terms we have used to describe attentional processes derive from our own immediate experience of processing information and as such are superfluous, redundant with processing itself. What we perceive of as our own attending is our own processing. Equating information-processing itself with the terminology of attention would represent a simplifying assumption. Take for example the question, "Can one process something to which one has not attended?" or conversely, "Can one fail to process something to which one has attended?". Though these sound like meaningful questions, with our simplifying assumption they become "Can one process something which one has not processed?" and conversely "Can one fail to process something one has failed to process". Obviously, these latter questions have little meaning and reduce to rather absurd identities. While making assumptions does not directly answer questions, the unique outlook provided by the equation of attention with information-processing itself will, I believe, prove fruitful. The ramifications of dropping the word attention in favor of information processing will become clear in the model described below. At times, I shall state issues both in terms of the information-processing language of the model and in more traditional attentional terms such that the reader will clearly see the change in focus provided by the change in terminology.

Limited capacity assumption. A second basic and likely less controversial assumption is that the organism has limited capacity with which to process information. This assumption has been around a long time, the most widely used construct being that of "limited channel capacity" (Broadbent, 1958). (Inasmuch as we have considered attention to by synonymous with information-processing, it would be redundant to postulate that attention as well as processing capacity is limited.) Because the information-processing capacity is limited, the organism must select which information it will process (attend to). Though an obvious notion, the assumption that the processing system has limited capacity has very important ramifications for the distribution of this limited capacity. Improper management of an adequate amount of information-processing capacity can result in failure on certain tasks just as severe as that caused by limited capacity itself. The paradox of learning disabilities may find some resolutions in this notion. Though not mentally retarded, presumably a condition represented by limited capacity, the learning disabled child has adequate resources, i.e., processing capacity, but seems unable to achieve the desired complex behavior, as for example reading. As will be made clear following the elucidation of the model, it is likely that

many types of learning disability result directly from inappropriate processing.

The Nature of Information: An Overview

As used throughout, information refers to the various signals which the organism is capable of decoding. By decoding is simply meant the ability to make discriminative responses to the given information if necessary. Thus, the notion of information as used here carries with it an implicit statement about the organism's capabilities. What is information for one organism may not be for another. For example, a physician with considerable training is capable of reading subtle shading patterns on an x-ray which are indiscernable to the untutored eye. Though the information is potential on the retina of the naive observer, for it to function as information, the organism must be able to form a discrimination between the pattern of neural activity evoked by differing distal (external) stimuli.

Information as patterned neuro-chemical events. It is implicitly assumed that the raw data of information which serve as proximal stimuli consist of neuro-chemical events. It is further assumed that the neural events are read, i.e., interpreted, by the organism in broad patterns; it is a certain patterning of neuro-chemical events which represent the true proximal stimulus for resulting behavior. This point will be reiterated later but I wish to stress right at the outset that in not making our concept of information explicit, we have implicitly assumed that information mirrors our experience of external stimuli, that information is an integral event just as external stimuli are perceived as integral events, an L, a glass, a picture and so forth. Such thinking is insensitive to the likelihood that the objects we perceive as being in the environment are constructed from fragmented sensory data. Take for example a box. The information we process is not "a box" but a pattern of lines, angles, colors which throughout our experience we have become able to recognize as corresponding to an external object which we labeled "box." The information we are dealing with remains a multitude of neuro-chemical events, the patterning of which we have learned to associate with the label and associated meanings of the external object. We shall consider this point again below when considering the basic informational units, the analyzer output.

Heirarchy of information. A second aspect of information important to the present model is its assumed hierarchical character. Given the conceptualization of external events as repeating patterns of neuro-chemical events, one can readily conceive of some external events involving more complex patterns of these more basic units. Complexity may derive both from the number of individual units making up the pattern or the number of different types of units making up the pattern. The notion of types of units is considered under the heading Analyzers. Viewing objects or events as patterns of various numbers and types of informational units, one is quickly led to the realization that some objects or events can be recognized very simply by virtue of their being transmitted redundantly with few units of information while other events or objects require more units to make up the pattern.

One can relate this aspect of information to the concept of information within an information theory framework (Attneave, 1959). Imagine a visual display board made up of small lights which could either be on or off. The

amount of information in a stimulus is given by the number of lights that have to take on their appropriate on or off state for the observer to recognize the object. Thus a circle can be represented by relatively few of these lights taking on a specific on or off state while the corresponding visual grapheme corresponding to the word circle would require many more of the informational units taking on a specific state. The first letter of the word circle itself represents a more complex form-decoding task than is the recognition of the object to which the whole word refers. Thus, the picture of a circle is more easily recognized than the written word circle, by virtue of there being less informational units necessary to construct the object than to construct the written word. This example illustrates the likely general case that spoken and written speech represent two of the most demanding information-laden sets of stimuli. The important general point to keep in mind is that recognition flows from a specific patterning of informational units, allowing for minor stochastic variation in each unit. A pattern, not a unified event, is registered. Various stimuli presented to the organism require more complex patterns for their recognition than do others and hence some information is more difficult to decipher. Deciphering linguistic information, even with the redundancies of language, constitutes an analysis of patterns composed of an exceedingly large number of informational units.

Parallel Versus Sequential Informational Processing

In order to place this discussion more clearly in the context of modern cognitive psychology, let me point out the ramifications of the present conceptualization of information for the issue of whether information is processed sequentially or in parallel. Recall that this is also the issue of whether the human observer can pay attention to more than one thing at a time. Were he able to pay attention to only one thing at a time, information would necessarily be processed sequentially. Were he able to divide his attention, he would be able to process information in parallel. Although we at times feel we can listen to more than one conversation at a time, it is possible that all we are doing is rapidly shifting our attention back and forth from one conversation to another. Said in the terminology of the present model, all we are doing is alternately processing two streams of information. The redundancies in the language would allow us to predict, i.e., to fill in, what we do not actually hear.

The many experiments which have addressed themselves to this issue have found that for the most part processing of semantic material can only proceed sequentially, one message at a time. These experiments ordinarily utilize the dichotic listening paradigm in which two messages are simultaneously input to the two ears, a different message to each ear. To assure that the subject attends to (processes) one of the messages, he is required to repeat verbatim that message immediately after he hears it (shadowing). Upon stopping shadowing, he is required to relate as much of the information from the unshadowed ear as possible. Ordinarily, the subject is unable to recall any of the content input to the unshadowed ear, except the most immediately presented material if the two messages terminate at the same time. He is able to decipher whether the unattended message was presented in a high or low pitched voice but is unable to determine even whether the message was spoken in his native language.

The fact that the unattended message is not totally ignored has created some problems for information-processing theories like those of Broadbent (1957). The subject's being able to determine the relative pitch of the voice in the unattended ear and other demonstrations showing that some processing of the unattended message is occurring do not provide us a clear choice between the parallel versus sequential processing models. While it appears true that two semantic messages are not simultaneously understandable, it is also true that one semantic message can be coded while other aspects of the unattended to channel are also processed. It would be a terrible over-generalization to claim that all information need be processed sequentially just because two semantic messages appear to have this limitation.

In the present thinking information is thought to be distributed hierarchically with semantic material requiring considerable information-processing capacity while less complex (highly redundant) information, such as the registry of the physical features, pitch, requires less processing capacity. Up to the point where the processor's capacity is reached, information is seen according to the present model as streaming through in parallel. At the point where processing capacity is reached, selection of input becomes more critical. The dichotic listening situation, where two semantic messages are input simultaneously to each ear, represents a case where processing capacity is exceeded such that selection of one input over the other is required. As another example imagine one is standing examining a picture and another person engages you in conversation. Though you may have to stop examining the picture as carefully or feel yourself withdrawing resources from the visual analysis of the picture to attend to (process) the vocal input, one need not totally ignore (stop processing) the picture. Nor need one sit down to begin the conversation even though continued processing of kinesthetic feedback is important in maintaining one's balance.

Simultaneous processing is the rule rather than the exception. It is because we are so often dealing with complex semantic material that the issue of selective attention becomes so critical. Because semantic material requires so much of our capacity, dealing with this material frequently puts us in the position of having to reject inputs to which we would otherwise attend (process). Thus, the issue is not whether the organism processes information in sequence or in parallel but more simply what information gets processed at all given that not all of it can be processed. Thinking of various signals as requiring various percentages of one's total information-processing capacity, one can consider the ramifications of trying to process a message requiring 75% of one's capacity while simultaneously trying to process another message requiring 60% of one's capacity. If one favors the former one is left with only 25% capacity with which to register the information in the other message. Though this can be done in parallel, such a small percentage of the capacity is not sufficient to decode semantically the message requiring 60% of one's capacity, though capacity to register physical features does remain. If for one reason or another, one chooses to set for himself the task of deciphering both messages, he will have to share his capacity between the two messages and will experience processing sequentially.

As an aside, note here how the reliance on information-processing instead of attention deployment absolves one of the necessity of having to postulate that greater attention need be deployed to decode more complex information such as semantic messages. In this way of thinking, the greater attention we may experience in processing more complex information may merely be an awareness of a greater portion of our capacity being devoted to the task.

In summary, it would appear that the research paradigms utilized in studying attention and information-processing represent a limited, though certainly an important, information-processing situation. This is the special case where verbal information is being input simultaneously. The issue of whether other kinds of information besides verbal information can be processed in parallel is not determined by these studies. With the notion that information is arranged hierarchically (some events requiring more of one's capacity to decode than other events), one is free to construct a model of information-processing which allows one to utilize one's total capacity, analyzing information in parallel up to capacity level after which more careful selection of inputs is required. Such a model is described below.

THE MODEL'S COMPONENTS

Analyzers

Analyzers are receptor and neural cells acting in combination which provide unit information by which the external world is known. The analyzers carry the unit information to which the organism can differentially respond. An analyzer is not a receptor cell per se though a single receptor cell could logically function as an analyzer. Rather, receptor and neural cells can more typically act in combination to provide unique information about the external world. Each analyzer responds to a different aspect of the external stimuli. As used here, the term analyzer is synonymous with the basic unit cells discovered in recent years. Examples of these cells are line detectors, edge detectors, moving edge detectors, slant detectors, color detectors, movement detectors and so forth.

An exhaustive enumeration of the various basic analyzers is not presently possible, nor is the issue clear as to whether these basic analyzers all represent innate capacities of the organism. While it is highly likely that many of the basic analyzers are innate, it is also possible that early experience provides a necessary condition for the growth of some analyzers which are formed from more complex combinations of sensory receptors and neural cells. The issue is more properly of concern to neurophysiologists than to the level of analysis with which the present information-processing model is concerned. What is most important here is that the signals with which the organism deals are composed of unit information from these basic analyzers.

The analysis of informational patterns referred to previously is based on these analyzers which provide unit information making up the complex pattern. Thus, as is more clear now that analyzers have been introduced, informational patterns can vary by virtue of the total number of analyzers involved in defining the pattern produced by some object or event and in terms of the number of different types of analyzers required to convey the meaning of that external object. From the point of view of the present model, the total number of units of analyzer activity required to convey the information is thought to be more important than the number of different analyzer types involved, though this issue is considered further when the problems of forming channels of information from these basic analyzers are discussed.

An interesting developmental issue concerns whether some of the analyzers are more basic than others, thereby forming a hierarchy of analyzer inputs. It could have important ramifications for perceptual development were different

organisms to have different priorities with which information were transmitted to higher centers. However, these issues are not specifically germane to the present discussion.

Channels

Our conception and immediate experience of our environment is no where near as fragmented and detailed as would be suggested by the workings of the analyzers alone. Rather than edges, moving edges, angularity, specific movement and the like, our experience is integrated into larger units. These larger units of experience are termed channels. The major importance of channels is that they are the basis of our ability to process selectively portions of our environment. By forming larger units made up of various kinds and numbers of sensory analyzers, the organism acquires the ability to dimensionalize his stimulus environment; this formation or construction of the environment into larger units is a necessary first step in allowing the organism to inhibit processing portions of this stimulus environment in favor of processing other portions in more detail. In forming hierarchical units from the more basic analyzer information, the organism is able to inhibit the firing of all the component analyzers for any given channel.

There are two basic types of channel formation that need to be considered: first is the channel formation that takes place within a developmental context. From the basic analyzer information, how does the developing organism come to construct the channels that it does? Second, at any given time, how does the organism constitute from the information available from the analyzers a channel, discontinue that channel and reconstitute another one? Though these two types of channel formation may appear distinct, they are mutually interdependent as the selection of one aspect of a stimulus field presumes the previous development of the channel groupings utilized in that selective enterprise. I shall deal with these two issues in turn.

Channel development. From the data the analyzers provide the informational array (discussed below), the developing infant begins to recognize the repeating nature of patterns of analyzer firing. These regularities in the firing of the various analyzers are, of course, correlated with the presence of distinct and likewise repeating objects or events in the environment. Thus, an object in the visual field, for example, becomes known by the repeated pattern of firing of the analyzers responsive to the various dimensions of the object. Recognition of any given object then is not so much an issue of an exact duplicate "recognition response" so much as it is whether a sizeable enough portion of the total responding analyzers form a pattern sufficiently like that when the object was previously presented. Slight changes in orientation, in lighting, and so forth may initially be sufficient to cause the organism not to respond in the same manner to the object as it did previously. However, with repeated exposures, the recognition of the object becomes based on a much broader and more complete pattern of analyzer firing. What is stressed here is that the recognition response is based on the "reading" of a large pattern of information and hence minor variations in the pattern can be tolerated without failure of the recognition response to occur. As we shall see below, this view of stimulus recognition, as a process of interpreting patterns of analyzer firing, has discinct implications for traditional visual search and pattern recognition experiments. As

will be detailed more thoroughly below, the process by which analyzer data are pooled and the regularities in the pattern of analyzer data recognized is termed integration. I choose this term because it implies a constructive nature to the recognition learning (stimulus learning) process. It is as though from the total information available about the object or event, the organism learns to read that pattern of input which hangs together in time and over repeated trials. For accurate and thorough knowledge of any object in the environment, the organism needs to pool information across basic analyzers from many input sources. This is the process of integration.

An important issue is the relative contribution of the organism's endowment versus his experience in forming channels. The process of recognizing repeating patterns of neural data from the analyzers in itself requires no assumptions about the inherent meaning of these signals; the organism could construct a conception of the object or event simply from the repeating patterns, the elements of which having previously acquired meaning through past integration. However, the physiological evidence of basic analyzer types such as line, edge, moving edge detectors and the like argues against such a "blank slate" view. While this model still contends that it is the reading of patterns of analyzer data which is critical to understanding and recognition of the external world, the notion of analyzers inherent in the model is that they can provide and do provide rather specific information about the nature of the external object. There certainly is not space here to disentangle the philosophical issue of whether the organism truly does begin as a "blank slate" or whether there is such a thing as innate ideas. I am simply suggesting that a combination of the two positions seem tenable from the present data, that is, that the firing of certain analyzers has inherent meaning but that the patterning of these analyzer data has to be learned (integration) of the organism is to know its environment.

Given that we are positing specific types of analyzer data, we must allow for the possibility that there are individual differences in the type of analyzers that have ascendance from one organism to another and that within any organism the likelihood of a given type of analyzer transmitting data successfully to higher centers for analysis is given by its relative position in a hierarchical ordering of the analyzers. This is only to say that one need not make the assumption that at or around birth, the transmission of all analyzers is equally likely. Though a fine point to some extent, the notion of a hierarchy of analyzers has critical implications for determining the total impression the organism will have of any given external object. This point is made clearest by extreme cases where sensory impairment occurs: deaf children, for example, would be expected to have a very different total impression of a rattle by virtue of it being void of the auditory dimension. One can readily see that the number of questions suggested by this conceptualization of the perceptual learning process are immense and call for a more detailed statement of the nature of the integration process named above. I shall put off this task until after the model's components have been described.

The integration process by which regularities in the input from many analyzers are recognized works in conjunction with inhibition. Inhibition constitutes the mechanism by which those analyzer data which are not repeatedly correlated with a given object or event, i.e., constitute random variation, can come to be ignored (not processed). This inhibitory process likely does not work on each analyzer individually but is able to function on classes of analyzers. Such an assertion certainly does posit a specific anatomical organization.

Specifically, it is required that data of a given type, for example, data from a moving edge detector, need be organized in a relatively few locations so that the inhibition of information from the moving edge detectors can be efficiently inhibited. It becomes a question for basic physiological research to discover how the basic analyzers combined to provide data and at which loci in this combinatorial structure inhibition is physically possible. A likely possibility is that there is a hierarchical taxonomy of analyzers which allows the organism through an inhibitory process to suppress the firing of large classes of analyzers. For example, movement detectors of all kinds may be related in such a way that the organism can temporarily become less receptive to all movement in the visual field. Similarly, color may be inhibited. Or, alternatively, certain portions of the color spectrum may be able to be inhibited independently. The central point here is that a structural organization of analyzers, taxonomic in nature, is hypothesized to exist and that this hierarchical organization allows the organism to suppress large portions of potential data. Whether the hierarchical organization is built up through experience with certain objects in the environment or whether this hierarchy is initially part of the anatomical under-pinnings of behavior certainly requires detailed study.

Channel formation. Within the context of the present model, perceptual development heavily involves the organization of analyzers into channels appropriate for recording the objects and events that intrude upon the organism and later those events that adults and society have highlighted for particular analysis. At any given point in time, the organism can select from the channels potentially available to him that which he wishes to analyze. Depending on the task the organism sets himself, the channel will be more or less broad, that is, will contain as figure a variable amount of data. In selecting a given portion of the stimulus field for more detailed analysis, other portions of the information being analyzed need to be curtailed given that the organism has limited processing capacity. To illustrate, the level of information extraction pertaining to the location and speed of moving automobiles requires greater capacity than is generally devoted to them as one walks along a sidewalk. Consequently, upon reaching an intersection, one must restrict processing other events, for example the conversation with one's companion, in favor of analyzing the critically important velocity of passing automobiles. Though the person need not totally fail to process a given class of analyzer information, e.g., passing automobiles, neither can he process it maximally given the concurrent demands on the processing system the conversation represents. However, when those data become more relevant to the organism, e.g., at the intersection, he can redistribute his inhibitory capabilities in order to devote a larger portion of his processing capacity to the more critical information at hand. At this point in time, one's speech output and understanding will have slackened as information about the passing cars is analyzed.

Articulation. Articulation is the process of forming informational channels. A person with extremely broad processing (global attention) experiences the world passively, while the person with discriminating processing asserts more control over his perceptions. Articulation can be extremely fluid, the person being able to group and re-group analyzer data through differential use of inhibition.

An example will illustrate how the same information source can give rise to different channels. Let us look at what kinds of channels a person

could form in the visual modality. Examining the environment around him, one could identify a central object in the field such as a chair. One can further distinguish the chair's color, the chair's form, and even get a kinesthetic feel for how heavy the chair is. One can further analyze in terms of the diagonal one feels in the chair or its verticals or how straight and stiff it appears, and so forth. One recognizes how articulated this description of a chair has become. Such articulation depends on one's ability to process the relevant analyzer data while inhibiting others' even though also evoked by the same chair. Alternatively, the chair could be treated globally, processed only to the point and only along those dimensions necessary for generating sitting behavior. This articulation ability may be extremely critical for intelligence and creativity in general. It is an ability to see the environment in various ways; because one is able to look at the various channels sequentially, one can become responsive to more aspects of one's environment than would be possible were one to deal with the total stimulus on each occasion.

To be certain that this point is understood, let me clarify the argument further. Given that the processing system is assumed to have limited capacity, only so much information can be deciphered at a given time. If one is able to isolate certain portions of the information into a separate channel and then analyze that channel exclusive of others, the detail of information that can be processed will be much greater than if the broader channel information is filling the processor. Thus, in the chair example, though we do not generally analyze a chair sequentially in terms of the various subcomponents of that chair, we can do this and learn much more about the object in so doing. The critic of art most certainly is well-versed in this technique. The present model posits that the critic's detailed appreciation comes from a considered examination of aspects of the stimulus that could not be possible were the total stimulus dealt with at the same time. Thus, while the global view is efficient, it does not lead to a careful consideration of all the information available. One requires the ability to form finer, more articulated channels which can then be processed more completely to the exclusion of other information to gain more articulated knowledge.

The global view has the greater disadvantage not simply in providing less information but has the added disadvantage that this superficial information leads to more rapid satiation (disinterest). Consequently, the person is required to look elsewhere for something to interest him. The success of the orienting behavior in finding new stimuli of interest will likely reinforce these tendencies to shift processing (attention) rapidly and hence reinforce a pattern of processing that is quixotic in its treatment of the information potentially available. Conversely, the child able to form more highly articulated channels avails himself of more information and will utilize these finer channels to the point that they prove useful or continue to be stimulating to him. (The apparent circularity of this final assertion is recognized but will later be shown not to be circular within the proposed model.)

The general point one need keep in mind is that the information potentially available is the same or nearly so for all observers (except for cases of organic damage). The fact that one takes a highly global stance indicates his disuse of much of the information and its subsequent inaccessibility for him. Were he able to eliminate from considerations some aspects of the environment in favor of some smaller set, his understanding would become more articulated.

Summary. Channels are the collection of analyzers which are processed as a set; as such, various analyzers at times may be components of different channels. Channels are continuously constituted, discontinued, and reconstituted. The amount of information one can transmit over any given channel is determined by the organism's central processing capacity. We can either process less detailed information about a broad information channel as when taking in the arrangement of a room or we can analyze a portion of that room in more detail and hence in more depth as when we examine a specific picture hanging on the wall. In the first case, our channel is very broad but lacks detail where in the latter case it sacrifices in breadth what it gains in clarity and depth of information extraction. The types of channels the organism develops are likely a joint function of the hierarchy of initial analyzer output to the higher centers and the organism's experience and reinforcement history, this final point being considered further below. The training variable may be as important as the organism's more basic endowment. A child who has found a global style acceptable may in a very real sense make the more articulated information potentially available to him less available than it is to a child without the experience of rejecting this finer level of analysis. From the channels potentially available to the organism, it selects some of the information as central of "figure" by inhibiting those analyzers not deemed relevant to the extraction of the figure's information. Through either the natural hierarchy of the analyzers or through a developmental process, the inhibition of various analyzer-combinations becomes more efficient, thus allowing more rapid processing shifts from one channel to another.

Informational Array

The informational array is the central concept of this theory. The informational array can be likened to a television picture tube or photographic paper in that it consists of a myriad of elements which can take on different informational states. The observer interprets this information not through a point by point analysis of each informational unit but by a more global patterned reading of the information. Models which implicitly treat information as though it were a single stream of neural signals have been misleading. Recognizing that most of the objects or events to which the human organism responds are sufficiently complex to require the firing of huge numbers of neural cells, it is more likely that the process of recognition involves the simultaneous reading of a huge collection of varied, basic analyzer data. Recognition is based not on the presence or absence of a single element but on a more stochastic process which requires the analyzer data to be only a reasonable approximation to the neural data previously aroused by a given stimulus. Some variation in analyzer firing can be tolerated while still allowing the organism to recognize accurately the object as being the same. The degree of variability, some due to the unreliability of the neural system itself and some to the actual variability in the external object, and the organism's practice in recognizing the stimulus in varying contexts will determine whether correct recognition occurs. Thus, in a very basic sense the organism recognizes a highly complex pattern of basic analyzer data, not an object. This basic distinction has critical implications for one's whole view of information-processing.

Array Size. Array size is limited in recognition of the assumption that processing capacity is finite. Therefore, it is of critical importance what

information the organism allows to fall on its informational array. Though one may have a large capacity, i.e., a large informational array, efficient information-processing requires that the task-relevant information comprise a high proportion of the data on the array. Because the organism needs to select the appropriate information for task solution, a large informational array alone is no guarantee of adequate information processing.

The major point about array size is not so much that it varies from one person to the next, but rather that it is always smaller than that required to display all of the information being gathered by the organism's sensory system and certainly smaller than that required to display the information the organism has stored. Thus, it is important to recognize that the informational array corresponds to that information which has effects on the organism's behavior (is being processed), not that which is being received by the sensory system. However, in making this important distinction, I wish at the same time to make it clear that what is being processed is not synonymous with what the psychologist calls his stimulus materials. Recall that the present model posits that up to the limit of one's processing capacity (array size) information can enter the array in parallel. Thus, a person encountering a verbal stimulus, while likely having that information represented on a portion of his array, will not necessarily have to eliminate all other information. For example, the feedback from his own musculature, random noise in the testing situation, thoughts, either task-relevant in the form of self-instructional strategies or task-irrelevant, may be part of the organism's informational array from time to time. Consequently, the information available to the organism at any point in time, i.e., that present on his informational array, may be highly complex and drawn from many sources. Positing as this model does that information is organized and analyzed as patterns on the informational array, the model opens up tremendous possibilities for understanding complex synthetic behavior. This point will be re-introduced later.

The informational array in containing analyzer data drawn from many sources is consequently in a continual state of flux. Obviously, the rules governing the change in the information allowed onto the informational array from one moment to the next would constitute the most basic information-processing issue. Note that this issue is essentially the same as that of attentional deployment, that is it asks from one moment to the next to what will the organism attend. However, I believe the direction one looks for answers to these two questions would be different.

Basic Functions of the array. The notion of an informational array is critical in that it represents the organism's immediate cue base. It is the true proximal stimulus. As such it is critically important in determining the contents of subsequent informational arrays and hence provides continuity to the organism's behavior. This point will also be re-introduced later and become clearer following a more complete description of the contents of the informational array. Second, the notion of an informational array is important for it provides a mechanism for intersensory integration. As Birch has frequently pointed out (Birch & Lefford, 1963), the human organism's exceptional information-processing capacity is distinguished not by its possession of any individually strong sense capability but rather by the ability to gather information from many sensory systems and derive a synthetic understanding of his environment. Integration will be discussed below but the reader should note at this point that the

informational array provides the mechanism for the simultaneous reception and response to data arriving from different sensory sources.

Further, the notion of an informational array provides a mechanism for the synthesis not only of sensory data but for the unification of sensory data with that already stored. As noted below, the informational array is capable not only of receiving input from sensory sources but also from storage, thus allowing the possible integration of new data with that previously received. The informational array, serving as a central hub, organizing the organism's behavior, opens up many new questions concerning the functioning integrity of the human organism. These later possibilities will be described following a discussion of the contents of the informational array.

Contents of the Information Array

A description of the contents of the information array needs to be artificial in that the informational array is continually in a state of flux. Consequently, no single description ever holds true. Thus, what I shall describe here are the kinds of data potentially capable of simultaneous presence on the array and caution the reader to recognize that all of the possible information is typically not on the array at the same time.

There are four major types of information which can fall on the informational array. These include (1) sensory analyzer data, (2) feedback and efference from the motor system, (3) bodily sensations other than the five senses and (4) mentation. I shall describe these in turn.

Sensory analyzer data. Informational-processing models normally restrict their applicability to the processing of sensory data. The present theory is concerned with these data also but in a somewhat different manner. First, as has been noted above, the sensory data received by the organism constitute more than those labeled stimuli within the context of a psychological experiment. It is recognized, for instance, that distraction signals, "background" cues, the subject's need state and thought process may all be represented on the informational array even though they may not be relevant to the information-processing task at hand. This assertion provides a framework within which to understand experimental paradigms which require so-called divided attention. Consider the incidental learning paradigm: whether or not incidental data are processed will depend upon the organism's mechanisms to make the processing of the subject-defined task-relevant information maximally efficient. If the incidental material is not inhibited due either to S's inability to apply the necessary inhibition or to his definition of the material as task-relevant, his "incidental recall" will be high. Thus, as the organism gains inhibitory control over material he sees as task-irrelevant, his "incidental recall" will drop. The issue is less one of divided attention than that of understanding the task and being capable of applying the appropriate inhibition to irrelevant material such that maximal array space is given over to the central task (cf., Maccoby & Hagen, 1965).

A second example of a paradigm dealt with in attentional terms which can be alternatively understood within the present framework is the shadowing procedure within the dichotic listening paradigm. The present model assumes that the array size is too small to represent the neural patterning corresponding

to two verbal messages. Consequently, information from the unshadowed message is not allowed sufficient space to be semantically decoded, though the more basic aspects of the signal, for example its pitch, is discernable. Any portion of the unattended to signal will be sufficient to determine its pitch quality while a much more thorough analysis of the array patterns is necessary to discern its semantic content. Attentional switching models have had difficulty explaining why any of the unattended to material is received. Solutions to this problem have taken the form of attenuaters attached to the unattended to channels. The present model is more in agreement with these notions but circumvents the need to introduce attenuaters by positing a parallel processing system with limited capacity. Paradoxically, in this instance where the subject is instructed to attend only to one ear, reception of the pitch qualities of the unattended to message constitute more a failure of the inhibitory process to keep the unwanted material off the information array than it does the achievement of so-called "divided attention."

The capacity of the normal human organism is such that the content of the sensory data on the informational array is highly multimodal. One need not shut one's eyes or block one's ears or reduce kinesthetic cues by attaining a resting position in order to process material through a given sensory system. We know monitoring of (so-called) unattended to signal can occur as evidenced by our ability to note stimulus decreases in these sensory systems when they occur. Also, certain words of high signal value such as one's name or simple tones the S is cued to expect are registered even in the "unattended" ear. It would appear more parsimonious (and consistent with the present conceptualization) to hypothesize that these exceptional stimuli processed in the "unattended" ear require very little array space and hence can be processed in parallel with the shadowed message. Increasing shadowing demands or the complexity of the signal in the unattended ear as by requiring that the S search for the word "tone" rather than an actual tone should result in reduced reception in the unattended channel. Other predictions are possible. The important point, though, is that the processing explanation is much simpler than the attentional one while still being able to account for the phenomena. Second, routine input constitutes noise in the psychophysical sense such that minor variations in signals either produced by actual minor variation in external events or by the unreliable firing of the nervous system itself can be ignored by the organism. The details of how this system might work and a sub-model for it are presented below. At this point it is only important to note the importance of unselected sensory analyzer input on the informational array and how the amount of unselected analyzer data fluctuates with the central task at hand, decreasing as the informational demands of the central task increase. Thus, for example, under high load tasks such as reading a technical book, the detection of changes within the auditory sphere, already inhibited by the reader, will be reduced even further. Stated more generally, the intersensory capabilities of the organism will be markedly reduced when strict or excessive demands for processing are placed on a single input channel.

Feedback and efference. A second category of information present on the informational array is the feedback produced by the organism's own activity. This feedback includes the kinesthetic sensations from the musculature as well as the auditory feedback from one's own vocalizations. Efference, referring to the organism's registry of his own output commands independent of feedback, is also included here though no unique theoretical significance is ascribed to it.

These data are thought to function in a manner similar to the sensory analyzer data described above. What is most important to consider is that these feedback data are an integral part of the informational array of the functioning organism and hence can enter into the data pattern which constitutes the basis for recognition of objects and events. As the work of Held (Held & Bauer, 1967; Held & Hein, 1963) and others has shown, the importance of the motor system in simple perceptual development is much greater than we initially considered; it is critically important that we introduce these feedback components into the model in such a way that they become an integral part of the organism's cue base. As part of the informational array, feedback from the organism's actions provides the stimulus continuity for directed behavior. In its most basic sense, feedback from a given type of activity may itself be an integral part of the cue base which generates more activities of that same kind. This deduction derives in part from observation of subjects in delayed auditory feedback situations and sensory deprivation situations. In both of these situations the normal input that the organism is used to is significantly disrupted. In the case of delayed auditory feedback, the delayed perception of one's own speech tends to block production of further speech suggesting that the cues of hearing one's own speech or speech production itself are useful in performing further vocal behavior. Similarly, in the sensory deprivation situation some of the subjects report losing directive control, not only of the sensory apparatus which has been denied input but also of the thinking processes. This latter example suggests a greater continuity between thinking and sensory processes than has normally been allowed for in information processing models and is remedied to some extent in the present model by introducing mentation onto the informational array. These examples suggest that the absence of feedback where it is usually present will cause performance decrements, at least until the organism can learn to function under the new cue conditions. The problem the organism faces here is two-fold; first, he is trying to operate in the absence of eliciting cues which this model contends the feedback provides and second, in accord with the signal detection model described below, he naturally will process immediately that information which may explain the absence of the cues usually present. Hence, denying the organism his usual feedback prompts him to examine what has happened to the cue base as well as eliminating a portion of the cue base used to generate further behavior.

Bodily sensations other than the five senses. These data potentially available to the informational array include certain aspects of organ functioning such as heartbeat, respiration and so forth as well as cues from need states such as hunger, thirst and sexual tension. These all may function in combination with mentation (see below) to produce the experiences of emotions and needs as we perceive them phenomenologically. They are listed separately from the senses because their monitoring is not required. Further, though their data can be processed directly, other cues from the senses or mentation can come to signal these need and emotional states as exemplified by Schachter's theory of obesity (1971) making these raw data more expendable. Lacking the demands of consensual validation present in sensory reception, the bodily sensations are more autistic in nature and can in most cases be substantially disregarded by the organism under certain conditions. Their importance, however, for the fully functioning organism, as has been addressed by Carl Rogers and those involved in sensory awareness, prompts insertion of them here in the interest of completeness.

Mentation. The final category of information potentially available on the informational array is broadly called mentation and comprises two broad categories, thought and non-verbal ideation. So little is known about non-verbal ideation that though it may function differently from thought, it is considered under the same heading with thought until we discover enough about it to force its separate listing.

It is not typical to include thought in an information processing model, though it is represented in research to a limited extent under the guise of "induced sets." The cue function of thought is generally acknowledged but is seldom integrated into theory. In the present model, thought as an explicit command or as an implicit directional behavior such as a set is placed in conjunction with other cues as part of the organism's cue base. Whether or not he will follow the directions of thought or those of other aspects of the cue situation or some combination of the two becomes then an empirical question. The reader familiar with Luria's (1961) developmental research on how language comes to direct the behavior of the child will see the obvious implications of inserting thought in this context.

The inclusion of mentation as one of the categories of information that comprise the informational array is a recognition of the phenomenological observation that the same processor which decodes incoming sensory information is also that which calls upon its stored information to be used in thought. Stated more simply, the organism can process external input or it can process material previously stored. This model allows these two to be functionally similar if not entirely identical.

Thought can enter into information processing not only in a fashion parallel to incoming sensory stimulation but can also feed back onto the array in a fashion similar to kinesthetic feedback from the organism's motor behavior. For instance, sensory input can evoke mental activity which can take precedence over the sensory input on the person's informational array. One can recognize this experience when listening to another talk; while at one point listening to the speaker, moments later one finds oneself thinking about what the speaker has said and realizes that the last few seconds of speech were not adequately processed. As a feedback system, thought competes for array space and can function therefore to limit incoming sensory data as well as provide new components to the informational array.

Thought can also be important when it shares the array and becomes part of the neural pattern evoked by other inputs. Thought can hence interact with sensory inputs, input from the need and bodily states, and with kinesthetic feedback. The important role of induced sets in affecting perception is well known as is Schachter's theory of emotion (1965) which posits a similar integration of bodily and thought processes to explain phenomenologically unique states. The present conceptualization further broadens the integrational possibilities and suggests new avenues of research. For example, can perceptual judgements be altered by systematically varying the content of the subject's thought during stimulus presentation?

Array topography. The informational array serves as a central construct for this processing model. It is an integrational mechanism capable of the simultaneous display of a fixed amount of information derived from the four major sources described above. Array size, indicative of the organism's

capacity to treat information simultaneously, is likely an important individual difference variable although it is likely overshadowed in importance by the efficiency with which the organism uses the capacity it has. Extremes of mental ability such as those represented by mental retardation may in part be more linked to array size while those characterized as learning disabilities may be more characterized by an inefficient use of an acceptable capacity. In the former case it is interesting to note that the programmatic work of House and Zeamen (1962) has shown quite conclusively that the mentally retarded's central problem concerns an identification of the proper stimulus dimensions relevant to the task at hand rather than to deficient associational processes. Reduced array size results in a sequential handling of the stimulus dimensions where a larger capacity allows for the simultaneous processing of greater amounts of information; hence, it takes the retarded person longer to select the appropriate information.

More typically, information processing by the normal organism involves the efficient use of the limited size array. It can be detrimental to task performance to allow onto the array (1) task-irrelevant sensory information, as for example auditory cues during a reading task, or (2) excessive kinesthetic information not relevant to the task at hand, or (3) information derived from the workings of bodily processes such as one's feeling of hunger or thirst during an education task, or (4) greater amounts of ideational material than are either appropriate for the task or which by virtue of their amount decrease the ability of the organism to process the task-relevant input. The obvious deduction is that the control over the information one allows onto one's informational array constitutes the control issue in information processing efficiency. This gives special prominence to the inhibitory mechanism which serves to impede the flow of information onto the informational array. If the organism is unable to inhibit the information coming either from external sources, from bodily sensations, from thought processes or from its motoric feedback, he comes under the control of events in no way relevant to the task at hand, i.e., "distractors." Gaining control over what constitutes the information on one's informational array would represent the paramount developmental achievement of childhood.

The contents of the informational airay will at all times be heterogeneous with respect to the four categories of inputs described above. The important question is not what is being "attended to" but what proportion of the array is devoted to carrying the information from the various possible sources. "Selective attention" in this context concerns the degree of processing of one type of information relative to the processing of others, rather than a qualitative difference in attention. For example, under reading conditions, the task requires that a considerable proportion of the array be given over to visual information particularly that from the various analyzers involved in discriminating form. However, all processing of auditory input has not stopped. Take the following example: if a student is reading a newspaper during a lecture and the professor, noting the student, stops lecturing causing a reduction in the noise level in the room, more than likely this student will perceive the decreased noise and look up to encounter the embarrassing silence. At the same time, other material is being processed as for example the thoughts aroused by the material being read, the peculiar smokey odor of the lecture hall, the kinesthetic feedback registered as muscular discomfort, and so forth. These all will comprise at some point an integrated memory of the event. Two points are worthy of note here; the first is that the distribution of the information array space is flexible, being able to be redistributed from one kind of input

to another. The second is that even though an event has a central (task relevant) focus, many other aspects of the situation have informational value and are coded as a part of the experience. This latter point is discussed further below under a section entitled "Integration."

The issue of the informational array's flexibility, being able to be devoted to any of the types of potential information, is interesting to speculate on. Two possibilities exist, one being that certain portions of the informational array can only carry a certain type of information and if this information is not input a corresponding decrease in the ability of the information processing system would result. The second is that the informational array is totally mutable and can be given over to the representation of inputs from any of the sources. This latter position in the extreme would say that one type of information could totally fill the array where the previous position suggests that certain portions of the array are available only to given inputs and if those inputs are not forthcoming that space is wasted. This issue is of interest when studying processing disabilities; if one is unable to process visual information sufficiently, would one be helped by the reduction of information from other channels as would be suggested if the array is highly flexible?

Sensory Input Signal Life

As information's entrance onto the information array is selective, one must consider what happens to that information not selected. It was his dealings with this and immediately related problems that lead Broadbent to construct his influential information-processing model (1958). Broadbent had noted that two simultaneous streams of information were processed not in the order of their arrival one item from each stream being taken in succession but that the two streams were processed as sets, first one stream and then the other. To account for this phenomenon whereby the order of information retrieval was different from the order of information arrival, Broadbent postulated the existence of an "S" or sensory system which serves to hold the non-preferred stream of information while the preferred stream enters the "p" or processing system. This sensory system also served as a rehearsal mechanism by which the organism could be held for limited periods and then re-entered into the processing system. Though Broadbent's model has now been faulted on a number of grounds, it has not been criticized for ascribing to the same system (s-system) the function of holding both unprocessed sensory input and material from rehearsal. In addition, Broadbent's early model made no mention of a very brief memory which has since been termed as iconic memory within the visual sphere, echoic memory within the auditory sphere (Neisser, 1966).

There are essentially three potentially distinct information handling procedures to be explained here. One is the very brief memory for an event which the organism seeks to process, i.e., he has allowed the material onto his informational array. This type of processing is illustrated by Sperling's (1960) paradigm which presents tachistoscopic visual arrays containing more items than his adult subjects were able to encode totally. Using a partial report procedure, however, Sperling was able to demonstrate that a much greater portion of the information was available to the subject for a brief period following tachistoscopic exposure than would be predicted from the accuracy of the full report. Sperling concluded that there exists a very short-term visual information storage system which held the visual information long enough for the subject to read off the portion of it requested by the experimenter.

A second information processing procedure to be explained is akin to the dichotic listening situation used by Broadbent and the bisensory situation used by the present writer and his colleages (cf., Madsen, Rollins, & Senf, 1970). In these situations two simultaneous streams of information are presented to the subject whose task it is to remember both streams. With rapid presentation rates (two items per channel per second) subjects typically favor and are more accurate when recalling one stream of information followed by the other. This is the initial situation Broadbent discovered and was apparently critical in his thinking as he postulated the existence of the sensory ("s") system. In this situation, different from situation one, the unselected message presumably does not receive any processing but is delayed until the processing of the selected message. Furthermore, unlike situation one, information is presented sequentially to both message channels whereas the initial situation described presents visual information in a single exposure followed by a blank exposure field. Furthermore, the signal life generally shown for the iconic memory situation example is usually figured at less than one second for visual information while accurate recall of three sequentially presented visual items one second apart is able to be accomplished after the recall of the three simultaneously presented auditory signals (Madsen, Rollins, & Senf, VII, 1970).

The third procedure is represented by the classic experiments of Petersen and Petersen (1959) in which they presented trigrams to their subjects followed by variable periods in which the subject was occupied in a counting task to prohibit rehearsal. Report of the trigram following the intervening counting was accomplished with decreasing accuracy to chance level within 15 to 18 seconds. This last case is similar to a rehearsal situation in that the subject encodes the item and then occupies his processing system with some other material and then attempts at a later time to retrieve the initial item.

These three different experimental paradigms have lead to the postulation of different intervening processes. These processes are distinguished by their signal life, the first being extremely brief probably less than one second and termed iconic memory or in Sperling's terms VIS standing for visual information store. In the auditory sphere the signal life is somewhat longer, perhaps up to two seconds and has been termed echoic memory. In the latter case, where a trigram is recalled following an intervening period of irrelevant activity, the signal life as illustrated by accurate report lasts as long as 15 seconds. In the intermediate situation, illustrated by the dichotic listening and bisensory memory paradigms, the accurate report of the message processed second would appear to have a life of up to about four seconds. However, in this middle case, it is possible that the complexity of the information-processing task compels the subject to use the mechanisms of the first and third procedures and as such does not represent a different order of process but rather a combination of two procedures, one which we might term sensory signal life (visually, iconic memory and auditorily, echoic memory) and the second which we might call coded memory in recognition of the fact that in the Petersen and Petersen paradigm and in rehearsal in general the subject has already had the opportunity to code the information into a form appropriate for rehearsal even though rehearsal itself is prohibited. The distinction between coded and uncoded material on the informational array is described below.

The model being proposed here thus deals with these three phenomena in the following manner: the neural activity of the various analyzers stimulated by

an external object or event is thought to have a signal life which varies with (1) the specific analyzer, (2) the state of fatigue of the neural transmission system specific to the analyzer data, and (3) the interference from other signals being carried subsequently across the same neural tissue. The Sperling paradigm, in which a brief exposure is presented to the organism who is then post-exposure cued to recall a portion of that information represents a direct test of the signal life of the analyzers involved in transmitting the visual signal to the informational array. That is, the estimates made by Sperling represent, within the context of the present model, the signal life of the analyzer data on the informational array, i.e., a measure of informational array life. Those signals inhibited from entering the informational array or being given such a small area of projection on the informational array so as not to be decodable in very great detail would be expected to have the same signal life as those given much space on the array. Stated attentionally, unattended to and attended to signals have the same signal life. This postulate seems to be the simplest available given the data. The usable life of an uncoded signal comprised of many analyzer firings should be thought of not as having a fixed life but one which can vary somewhat, the iconic memory paradigm used by Sperling being one which maximized the signal life by (1) presenting a large, bright, clearly defined stimulus, (2) following this stimulus with a dark field to eliminate competition for the neural circuitry and (3) allowing time between trials for the receptor and neural system to recover. Under these nearly optimal conditions, signal life is only in the order of a second for the visual system, perhaps somewhat longer for the auditory system. Under more typical viewing conditions, signal life would be expected to be briefer.

Uncoded versus coded array material. The information of the informational array is of two basic kinds, one being non-linguistic raw data from the sensory system and from other bodily functions including kinesthetic feedback from the motoric system. The second type involves a coded representation such as what we term inner speech or thought. As mentioned earlier, there also exists a visual code analygous to our language code which we presently study under the label "imagery."

The notion of a code is very critical here because it allows the organism to translate material which takes a large portion of the uncoded informational array and represents that idea or information in terms of coded neural activity which takes less array space. In this sense a code is efficient. Second, a code is regenerable by the organism. While one is unable to reproduce in an exact, detailed fashion the complexity of a given stimulus input, one is able to reconstruct at a later time one's own "description" of that event. This reconstruction using a verbal or perhaps at times a visual code may in turn stimulate other associated characteristics of the initial experience; the whole recollection is immensely aided by the ability to reproduce a portion of a previous experience using a code.

Language obviously entails these two aspects of a code, efficiency and regenerability. Take, for example, the Petersen and Petersen paradigm whereby a trigram is presented to a subject which he is to recall following an interspersed period of irrelevant activity. All the information contained in the trigram including the size, spacing, width, color or orientation of letters can be reduced to a code representing a consensually defined content of the letters. Furthermore, this code is reproducable such that though the shape, size, orientation and other task-defined irrelevant characteristics of the

letters may not be recalled, the shape (names) of the letters can. It is the efficiency of the code and its regenerability together which allow for the phenomenon we know as rehearsal.

The coding process constitutes a shift in information on the array from a neural pattern constituted of rapidly fading analyzer data to a coded representation. Typically, this coding process is of an auditory nature though not necessarily so. Once coded the information has different signal life than that of the analyzer-based signal. As the Petersen and Petersen paradigm demonstrates, once encoded semantically, a signal without further augmentation has a life span of up to 18 seconds.

The more demanding of the organism's capacities the intervening activity between trigram presentation and recall is, the poorer should be the trigram recall. Such a relationship is important in that we are implicitly postulating that this signal life is characteristic of the coded material on the informational array and have not postulated that the coded trigram is shunted off the array into a buffer or "hold" system while the organism undertakes the interpolated task-irrelevant activity. Whether one postulates a hold system or asserts that the coded portion of the informational array maintains the signal has different implications; by hypothesizing that the signal remains on the array, it would be necessary to predict that more demanding interpolated activity, and that interpolated activity similar in content to the signal to-be-recalled, would interfere with correct recall, other predictions also follow. The main point here, though is that signal life on the coded array represents what we know as short-term (STM) memory (for verbal materials which have been coded by the subject). The interface between coded signal life (STM) and long term memory, an important issue in any information processing theory, must be delayed until after describing the flow of information from the information array.

The present model then posits two types of signal life: one is for uncoded (non-linguistic) material arriving from the senses, bodily functions, and kinesthetic feedback. This signal life is relatively short, measured in terms of milliseconds, though it varies with the type of analyzers providing the information, the state of fatigue of the analyzer transmission system, and the amount of information subsequently transmitted by that analyzer transmission system. A second signal life characterizes coded material. A very different set of variables likely influences this signal life, the most important ones being the salience and discriminability of the content of the coded item to the individual. To cite an obvious example, a subject named Bob would have little trouble remembering the trigram "bob" indefinitely. A person not named Bob would certainly remember the trigram "bob" longer than a nonsense trigram though perhaps not as long as the person named Bob. Thus, what I am suggesting here and what will be discussed again later is that the meaning variable studied by psychologists over the last twenty years is conceptualized as affecting the signal life of the coded array material.

The dichotic listening and bisensory memory situations do not readily fit either of these two conceptions of signal life. It is possible that in the dichotic listening situation with three items per channel presented at rapid rates of two items per second, the channel received second may be held as an echoic memory, i.e., according to the signal life of the basic analyzer data, and thus be consistent with the first type of signal life described above.

However, for slower rates and likely for the bisensory situation where the visual modality is involved, it is likely that considerable coding of the signals is occurring during stimulus presentation such that the subject is likely using a combination of coded signals and uncoded ones for the basis of his output.

Integration

Integration refers to two related phenomena, one being the assembling of input from a number of sources into a single experience such that recall or probing of a portion of this total experience may bring forth a remembrance of the remaining portions of the experience. For example, recalling or being questioned about some event in one's past, as for example a cottage one visited, tends to evoke not only the visual image of the cottage but the surrounding emotions, perhaps even distinctive smells and sounds associated with experiences there. Thus, integration of this sort refers to the coding of many aspects of an event into a common memory.

The second use of the term integration is that cues from different sources can become able to elicit a single recollection. A simple example is how a visually presented graphic symbol is able to elicit the same responses as an auditorily presented one, that is, the same word tends to elicit the same mental activity and the same verbal output. This notion that the equivalence of auditory and visual cuing function of words results from integration suggests a different model of reading acquisition than that commonly assumed whereby the auditory name of the word is thought of as a response item for which the visual graphic symbol is a stimulus item, i.e., paired-associate learning paradigm. To learn the meaning of a new word, i.e., a new visual cue, for which the person already knows the meaning of the corresponding auditory representation of the word, the task as seen as an integrational one would be to associate simultaneously on the informational array both the auditory and visual representations of the word such that the meaning derived from the auditory word could become associated with the visual pattern. This notion will be expanded in the second part of this paper concerned with reading and reading disability.

The basic assumption made here about integration is that the units of information on the informational array have the potential of being integrated by virtue of their simultaneity. Material filling the limited capacity informational array at the same time has the ability to be used as an integral part of the patterns of information coded by the organism. The greater the amount of information involved in the central task undertaken by the person, the less remaining room on the informational array there will be to display cotemporally associated information. Thus, for example, if one chooses to process another's speech, a highly complex signal, little room will remain to display associated aspects of the situation such as one's own bodily sensations, or one's own thoughts, or other input from the senses such as the visual characteristics of the situation. Nevertheless, even in high demand situations such as this, associated information is stored, as for example in remembering a past conversation recalling that it was very hot in the room at the time or recalling a dinner conversation and being able to remember what you each ate.

Span of immediate apprehension. Though the most basic parameter for integration is the simultaneity of items on the informational array, approximate

simultaneity may be sufficient. Persons with exceptionally long signal life for either raw data or coded input would be able to integrate events more distant in time and would be said to have longer spans of immediate apprehension. The span of immediate apprehension is increased not only by the longer signal life of the raw and coded material on the informational array but also by coding and rehearsal strategies adopted by the subject. Signal life is enhanced through coding, as coded material has a life measured in seconds while uncoded material fades in milliseconds. Also, because coded information on the array has the characteristic of being regenerable, the person is able to reinstate on the array certain coded aspects of experience for indefinite periods of time, thus increasing the likelihood that it will be integrated with other materials on the array. Use of the rehearsal mechanism to regenerate portions of one's experience in coded fashion likely accounts for a greater portion of the variability in the span of immediate apprehension than does the longer signal life some people may possess. A rehearsal strategy can readily double an event's active life with only a single repetition which represents a larger difference in signal life than likely would be the difference between the signal life of two individuals.

Capacity for integration. Man does not possess any extraordinary sensory capabilities but rather derives his superior knowledge of his environment through an ability to gather together information from a variety of sources and unite it into a single memory. This ability has been termed "intersensory integration" (Birch & Lefford, 1963). In the context of the present model, integration is related to three factors, one being the array size which places limits on the organism's ability to register information simultaneously, the second being the information load of the material on the array, and the third being coding and rehearsal strategies which extend the life of information and, hence, allow its integration with a greater amount and wider variety of other information.

Typically, information streams onto the informational array simultaneously, the person defining the central channel in such a way that all of the information to be integrated is allowed onto the array. An example would be the experience of a bouquet of flowers with aspects of color, shape, texture, odor, and flower names all finding room for simultaneous processing. Hence, the person experiences the bouquet as an integral object not as a fragmented series of colors, shapes, textures, smells, and labels. Though this point seems terribly obvious, one must recognize that it is possible to experience the bouquet differently, for example, by selectively processing the curvature of one of the blossoms. Such detailed processing of one aspect of the situation could tend to utilize so much of the array size (capacity) that the observer could fail to note the colors utilized in the whole bouquet, of the bouquet's odor, and so forth. Thus, this example illustrates that integration requires a processing strategy which defines the channel broadly enough to allow the information to be entered onto the array simultaneously. The greater one's array size, the more information-laden can be the material simultaneously represented for integration.

The more demanding the central processing task set by the organism becomes, as for example decoding spoken or written speech, or undertaking a complex non-semantic task such as crossing a busy intersection, the less array space there will remain for the simultaneous registry of input from other sources. Consequently, the stored representation of the total event becomes less dimensional, possessing

components from fewer sources. One notes, for example, how conversations stop or at least become fragmented when one crosses a heavily trafficked street. Such occurrences result from the subject's inability to process in sufficient detail the complex analyzer data telling him about the distance and speed of moving automobiles at the same time as the linguistic input or output. It should be able to be shown in an experimental context that integration will decrease as a function increased information demands of the central task.

What can be integrated? The informational array allows for the simultaneous consideration of a huge variety of information. The unique combinations of information possible are virtually unlimited. Even the simple reception of a seven digit number, for example, will process differently depending upon whether part of the informational array contains the thought that it is a telephone number or a sum of money. The first case will likely cause the person to group the numbers in a series of three digits followed by a series of four digits while the latter case will result in a different grouping, the exact grouping depending on whether whole dollars or cents are involved. It is to a large extent an empirical question whether information from the four different sources noted in the section on the informational array content above can be combined to form new products. By illustration, consider first the simplest case of looking for combinations of patterns within the sensory input system alone. The easiest way to approach this question is to ask how does an external object come to be known by the organism? According to the present model it is the simultaneous display, i.e., integration, of the sensory input from the object on the informational array that provides us with a total idea or memory of an object. A brick has a certain size, shape, color, texture, and is even construed to have a certain sound were it to be dropped on a hard surface. A violation of any one of these expectations about the brick would immediately be noticed because the total pattern on the informational array would be altered to that extent. Plastic flowers lacking odor or a known food cooked by another to a different texture than one is used to is immediately noticed as different from one's own conception of the object. The present model contends that it is not through a sequential checking of the object's properties that one notices these differences but that the total experience as defined by a pattern of informational firing on the informational array deviates in some significant way from a pattern previously established. Similarly, need states become an integral part of an experience and influence the total conception of an event as has been well documented by the experimental study of the effect of various deprivation states on the judgment of foods and other desired objects such as the experiments on the size judgment of coins by rich and poor children.

The interesting question which needs to be subjected to empirical test is whether thoughts can function in the same manner as need states, thus influencing the total analysis of an event by becoming a part of the stimulus complex used in registering the event. A recent experience makes me think that thoughts are able to function in this manner. Sitting across a swimming pool from a large box-like structure, I noticed what I thought were people looking at a rectangular board projecting almost vertically from this box-like base. From the way they were staring at the side of the board facing away from my view, I presumed it to be a sign, likely containing rules governing use of the pool. A few minutes later, however, a maintenance man came up to the box-like structure and looked down into it; immediately, it occurred to me that the rectangular piece of wood atop the box was not a sign at all but rather was the top of the

box propped open for easy access to the materials inside. These two entirely different interpretations of this distant object, I think, can be explained in terms of the different associated thoughts evoked by the actions of the different people involved in the two situations. In the first case the vertical, rectangular wooden board was seen as a sign by virtue of persons on the other side appearing to be staring at it while the second time in conjunction with the workman, it appeared as a top of the box into which he was looking. Though trivial, in and of itself, this example suggests a link between our study of thinking and our study of perception. The basic issue here is how the presence of specific thoughts affects the interpretation of sensory input. Perception as a personal experience modified by the individual's history may be mediated by his ever-present thought processes which can interact with sensory input to modify his resulting mental and behavioral activity. Desirability of a new food, for example, may be continuously rated low and actually disliked by a person possessing the cognition that new foods are in general undesirable. As Rogers has pointed out in his personality theory (1959), the evaluation of the experiences by an individual may be more heavily determined by his cognition about what other people think of the event than by the analysis of the perceptual and bodily sensations the experience produces in himself. Both of these examples suggest the possibility that thought can affect our perceptions and subsequent behavior. This theoretical conception which places both sensory data and thought onto the informational array suggests new experimental questions which deserve study.

Perceptual sets. The relationship between thoughts and perception as discussed in the immediately preceding section has received some study under the name "perceptual sets." Essentially a set is an internally generated readiness to receive a certain specific content of information or to code or arrange specific information in a certain manner, that is, to "see" a certain relationship between events. The very nature of a set requires that it be mediated verbally and hence is uniquely human. For an organism to be primed to receive a certain signal it must be able to conceptualize that signal prior to its presentation. Similarly to the basic assumption of the Information-Integration theory that our experience of attention results from the act of processing itself, our experience of a readiness to receive information, is assumed to result from information processing as well. Such processing could be the priming or pre-firing of a certain subset of cells which are going to be necessary to carry the expected information. As such, the experience of a set would constitute the transmission of information from the storage areas to the coded portions of the informational array.

The experience of a set or the readiness disappears when the information arrives. Such an effect could result from the coded array which carries the internally generated readiness being also used for the actual reception of the event. It is for this reason that the experience of being ready to receive information is unable to co-exist with the actual experience of processing the information itself. One cannot both experience being set to receive information and actually receive it at the same time.

The basic issue for the present theory is whether the notion of sets requires mechanisms in addition to those used in actual information selection. Recall that information selection involves the inhibitory mechanism through which channel formation operates. While a set would be thought to initiate the same inhibitory process necessary for the registry of the material expected,

an additional process is involved, already alluded to in the preceding paragraph. This is that the set produces on the coded portion of the informational array a representation of the event sought after. This representation on the coded portion of the informational array is an adequate stimulus for establishing an appropriate inhibitory pattern which will maximize the reception of the event in question. Furthermore, whereas the coded array already carries a representation of the events looked for, translation from the raw stimulus input when received to the coded portion of the stimulus array is made more efficient by virtue of their previous coded neural activity. Thus, sets aid reception in as many as three ways: first, they serve an alerting function allowing the subject time to increase his activation level as for example through increased muscular tonis. Second, the increase in the activation level can aid in the establishment of an appropriate channel if fore-knowledge of the expected signals is sufficiently specific. Third, by already having the expected information activated on the coded portion of the informational array, the translation of the raw input to the coded array is facilitated. These three functions should be able to be experimentally separated perhaps in a fashion akin to the recent series of studies by Posner and Boise (1971).

THE FLOW OF INFORMATION

Description of the model to this point has concerned itself solely with the constructs and their functions that define the theory. Only occasional mention has been made of how information moves through this information processing model. A flow of information through the model has not been stressed because the model is more concerned with how information is organized and how the organism uses this information to generate behavior. This focus stresses that information processing is more than a transduction of energy from an environmental event registered by the organism but rather represents a total adaptive response of the organism by which it continually maintains contact with its environment, using the information from the environment and from its own behavior continually to update its relationship with the outer world.

Information does not flow through the information-processing system as much as it is organized by it. Information flows to the informational array from a variety of directions. These include the transduction of information at the senses where the specific analyzers transmit information about unit aspects of the environment toward the informational array. The usable signal life of these various impulses output is a function of the strength of the initial input, the number of analyzers transmitting the information, the state of receptivity of the analyzers and the amount of subsequent transmission of information over the same analyzers.

In addition to sensory data, information from feedback and efference, and from the other bodily processes such as heart rate and respiration, also project onto the uncoded portion of the informational array. Information of this variety gains access to the information array by virtue of it being constituted as the channel of information to be received by the organism. Much of this information potentially available to the organism does not register on the array. However, more than that normally conceived to be the central signal, as for example a trigram in a memory experiment, is received by the organism; up to its level of processing capacity, information enters the informational array in parallel. Thus, even though the organism may be dealing with highly information-

laden semanic material, other aspects of the external situation such as features within the room, particularly irrelevant dimensions of the stimulus materials themselves, and so forth may become part of the effective simulus situation for the person.

In addition to uncoded array input, material approaches the informational array from the subject's memory. This material is coded by the organism in terms of an idiosyncratic code, likely heavily verbal in nature though the model does not rule out the possibility of other types of coding, for example visual imagery. The coded material differs from the raw input on the uncoded array in that (1) as coded material it represents an efficient subset of the raw material and (2) it is regenerable in the sense that the organism can produce upon its coded information array that pattern of information.

The information simultaneously present on the informational array is capable of being read as a total pattern such that materials from various senses as well as material from bodily sensations other than the senses and in addition material from thought processes can be simultaneously available to the subject. In this manner, the response to the information on the visual array can be heavily influenced by the thought or other bodily processes of the organism. The organism's capacity to form channels which allow the simultaneous display of information from these various sources is likely heavily correlated with the organism's creativity. Unique combinations of events simultaneously present on the array are unlimited and are further enhanced by the subjects with extremely long signal life and more importantly by the use of rehearsal strategies which regenerate coded material to make it available as part of the informational array for longer periods of time. The size of the array, i.e., the information-processing capacity, the subject's ability to construct channels which cut across the various informational input modes and his rehearsal strategies all will affect the amount of integration he achieves. This integration allows for memories to contain elements from many sources such that the presentation of a portion of the event can evoke memory of the entire event, thus providing the organism with extreme powers of recollection, having so many access routes to the various events he has stored.

Information of the uncoded array, just as that not permitted entrance onto the array, has a very short signal life, measured in terms of a second (plus or minus). Uncoded input can be maintained by applying a code to it thereby approximating its representation on the coded array. The uncoded event is only approximated by the coded representation, there being a loss in detail, in particular those details that the culture's language does not deem important. Though the coded representation loses information, integrational power is derived from its efficiency, longer signal life, and regenerability.

However, all uncoded information is certainly not first represented on the coded array prior to its evoking further neural activity in the form of thoughts and images. More typically one's neural activity, whether "mental" or motoric, flows directly from the uncoded input just as it does in the case of non-verbal infrahuman organisms which presumably do not possess the capabilities associated with the coded portion of the informational array.

Semantic information on the uncoded portion of the informational array (e.g., visual graphemes) may be special in this regard. Frequently, a person appears to translate linguistic raw input into coded form prior to its evoking some further neural activity in the organism such as thoughts and images.

However, some visually presented semantic material on the uncoded portion of the informational array may give rise directly to further neural activity without first being translated into the linguistic code. There is no *a priori* reason why the graphic forms cannot generate images just as the form of an actual object does; both require the same integration process to embue the form data with meaning, i.e., with derivative mental activity. In fact it has recently been shown that visual graphemes can be recalled without the benefit of the linguistic decoding process (Parkinson, 1972).

Information thus can enter the coded portion of the informational array by translation from the uncoded portion, as for example by reading a sentence or naming an object, from the subject's own memory, as for example by some recollection, thought or self-direction, on from the coded array itself through the regenerative process of rehearsal.

While the information array size (capacity) is limited, the boundaries between input from the various sources remain flexible. While it is unlikely the case that the total array can be given over to any small select portion of the available input information, the degree to which this is possible is a measure of the organism's capacity for detailed examination of an input. Within the Information-Integration theory, this selective ability is postulated to relate to the reticular activating system's ability to provide the inhibitory energy necessary for channel formation. The ability to divide one's informational array between input from a variety of sources, which also likely requires considerable inhibitory skill, is an indicant of the organism's integrational ability, of the ability to experience an object or event in a variety of ways and hence provide a more complex memory of that event which in turn allows for easier retrieval of that memory. Also, the uniqueness with which the person can construct channels from a variety of sources allows for the creative synthesis of material stored in memory brought onto the array through thoughts and input from the external world brought to the uncoded portion of the array by the sensory analyzers.

Post Array Information Flow

Not only must information be decoded but to have it understood it must be integrated with material already in memory. This relational process to stored material is critical to thinking. For example, a novel like *Gone With the Wind* is substantially different to an early adolescent than to one with broader experience, as is the case for any novel. Clearly there must be some liason between the semantic decoding of the signal as exists on the coded portion of the informational array and the use of the organism can make of this information.

An active process is implicated by which the information pattern on the coded portion of the informational array acts as a proximal stimulus for further neural activity. This active process is critically important as it is this process which maintains one's interest in the array material and hence governs heavily what portion of the information available will be selected in the immediate and distant future.

Given that there is obviously more to information processing than the literal decoding of graphic symbols or other aspects of one's environment, one

can speculate as to why one person's interest (that is one's processing) is maintained for a given material while another individual's attention wanders when presented with the same material. Similarly, certain stimulus presentations are more interesting for almost all persons than are others; what are the characteristics of these more interesting presentations such that they are able to demand access to the informational array? To cite some examples, why is a moving picture more interesting or at least continues to be processed for longer periods than still slides? Or why are color slides more interesting than black and white ones on the whole?

Viewing as this theory does, that attention is really a reflection of the presence of ongoing information processing, an answer seems readily available: this would be that interest (or attention) will wax and wane with the organism's ability to act on, i.e., to process and be stimulated by the information. The common expression "being put to sleep" as an expression of boredom is very apt in this regard. A person loses his attention and interest, becomes bored, and his "attention wanders" when the material striking his sense receptors, though able to be decoded, does not further excite the organism. Thus, it would appear that the mechanism responsible for determining what we process (attend to) is located subsequent to the informational array. Array material will be sought after in kind if it stimulates further neural activity, either "mental" or motoric but will be replaced by other information if it is not so stimulating. For example, one will discontinue reading when the physical feature analysis fails to stimulate further neural activity (thinking and non-verbal ideation-imagery). If one is compelled to continue reading, as for example by a class assignment, one experiences boredom and is continually distracted by intrusive thoughts or extraneous external stimuli. Though the physical features of the graphic symbols continue to be brought to the informational array, their failure to excite further neural activity initiates a shut-off process which will eventually terminate the selection of visual information despite the desperate self-instruction to "concentrate" being repeatedly represented on the coded array.

A second example illustrates another point. In looking at black and white stills the observer's color analyzers are essentially dormant as are the myriad of receptors sensitive to movement, as the information available in a still picture has to do with the form, contours, and shadings. These data may not be sufficient to fill the informational array, especially if the pictures do not excite thinking which will feed back onto the array. Failure to occupy the array, whether caused indirectly by ceasing to input information, which is not further stimulating, or directly by a barren stimulus environment, will result in the organism selecting input from other available sources. Frequently, these other sources provide task-irrelevant information and are hence, referred to as "distractors." However, the processing of these distractor data represents less the interruption of the processing system than it does the lawful functioning of a system which has been provided with a central task insufficient to maintain continued processing. This assertion is formalized in a major theoretical postulate concerning the motivational aspects of information processing and a model for the selection of information outlined below.

Progenerative Hypotheses: A Reinforcement Mechanism

If the organism is not capable of making discriminant responses to the informational array, the information will quickly become boring to him. For

example, the person who has a great deal of experience with line drawings can make finer discriminations and hence maintain his interest by keeping his processing array operating. How long, for example could a naive observer study x-rays even though the initial one or two may look fascinating. The rather obvious answer is that in being unable to discriminate the relevant cues, all x-ray patterns look very much alike and hence in a very basic sense do not have informational value for the novice.

Such a notion of interest-value, being based on the organism's ability to discriminate the input on his array, implies that it is the likelihood that information falling on the informational array will stimulate further neural activity which determines what information the array will select in the future. It is not the physical aspects of the processing task which support a person's interest, neither is it the content of the information per se that interests someone but rather it is what the content stimulates in the person. Within the context of the Information-Integration model, continued processing of a given source will be of a higher probability if that information stimulates further neural activity. If little neural activity flows from the array, then the array information has correspondingly little signal value for that organism. Consequently, in such instances when the organism is not further stimulated, one experiences one's attention as wandering, indicative of the fact that further information extraction is not occurring. The implications of the failure of the array information to stimulate imagery and thought will be discussed in the second major section of this paper dealing with specific learning disabilities in reading.

Information flow from the informational array. Theoretically, it would be possible for the organism to entertain information on the uncoded and/or coded portions of his informational array and have not later recollection of them. If the pattern of firing which in the informational array activates no further neural activity, then there will be no memory for the event after its signal life on the informational array has expired. It is likely that this extreme case seldom occurs, but may be approached in conditions of information processing pathology. More typically, almost any input has some meaning to the individual such that it is capable of evoking a network of neural activity. The character of this network activity has likely been approximated operationally by psychologists in their study of the associational matrix of semantic material and in terms of the concept of "meaning" as it is defined by associations.

Information on the coded array most closely corresponds to the term "short term memory" while any activation of stored material by the informational array could be described as "long term memory." The distinction between short and long term memory is that the coded signal and the span of immediate apprehension, augmented at times by rehearsal, roughly corresponds to STM while evidence for LTM requires that the neural activity corresponding to the event have ceased its representation on the informational array prior to its being recalled.

The material on the informational array gives rise to further neural activity. One can conceive of the process in s-r terms, the array pattern representing a unique proximal stimulus and the post-array neural activity the response. In highly practiced situations and in a very defined stimulus environments, very discrete and consistent mental or motoric activity will follow. It is likely that this extreme case seldom occurs, but may be approached

in conditions of information processing pathology. More typically, almost any input has some meaning to the individual such that it is capable of evoking a network of neural activity. The character of this network of activity has likely been approximated operationally by psychologists in their study of the associated matrix of semantic material and in terms of the concept of "meaning" as it is defined by associations. In more loosely controlled situations, the neural activity aroused by the pattern of neural events on the informational array will be less predictable. In the extreme case where a totally novel situation is encountered, the post-array neural activity will be highly variable. Situation here is not the external environment but the proximal situation represented by the informational array. Totally novel situations can derive from array data drawn from a number of sources, e.g., thought and sensation. Creativity may relate to the person's ability to entertain diverse information simultaneously on his informational array.

The post-array neural activity consisting of imagery and thought (imaginal system) and efferent firing has access to the coded portion of the information array and is continually monitored in a fashion analogous to the continual registry of sensory input. Thus, the pattern of firing on the informational array gives rise to imaginal and/or efferent activity both of which feed back onto the informational array to provide the cue base for further post array neural activity. Consequently, continuity of the organism's behavior is enhanced by feedback from both the imaginal system and kinesthetic sources as well as by the continuity of stimulation from the organism's internal and external environment. Thus, just as in the case of kinesthetic feedback where the motor system set in motion by the total pattern on the informational array provides feedback from which further behavior is generated.

Aside from the feedback function, it must be stressed in closing this section that the stimulation of the imaginal system represents a motivationally satisfying state for the organism. Material which stimulates the imaginal system will be sought after and brought to the informational array. The basic motivational premise here is that the stimulation of cell B by cell A will continue if B is able to stimulate some further cell C. If, however, cell B is unable to stimulate cell C the likelihood of A stimulating B will be decreased. Said within the constructs of this theory, if the informational array data (B) is unable to stimulate the imaginal system (C), then the likelihood that the informational array (B) will continue to receive information from those analyzers (A) will be reduced. Conversely, stimulation of the imaginal system (C) by the informational array (B) increases the probability that the analyzer data (A) will continue to enter the array (B).

THE SELECTION OF INFORMATION

A critical issue not ordinarily dealt with by information processing models derives more from attentional constructs than from strictly informational ones. This is the issue of what gets processed, said attentionally, what does the organism attend to? Most of the information processing research has been concerned more with the operating capabilities of the human system and less with its actual operating characteristics. A particularly interesting and important question when considering the information processing characteristics of deviant samples concerns why the organism devotes its resources to the processing of some information to the exclusion of other.

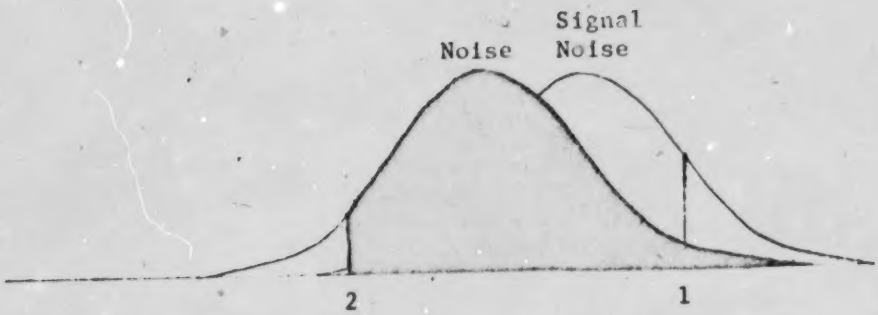
Signal Detection Model

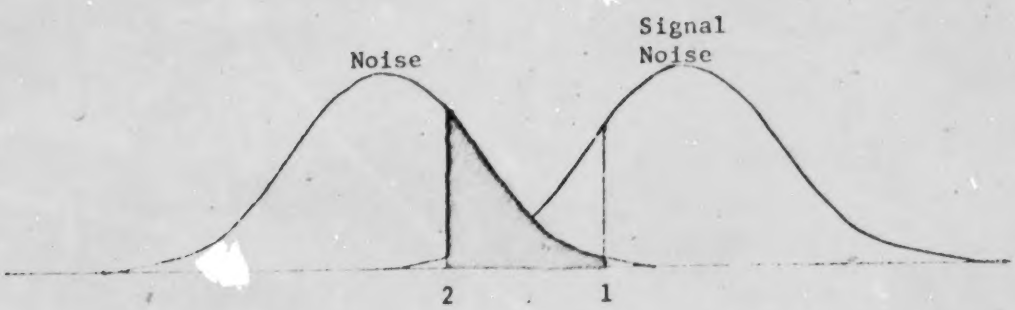
The most basic principle operating to sustain processing has been discussed in the section immediately above; information will be selected for analysis if it is capable of stimulating further neural activity. This postulate implicitly states that information is intrinsically rewarding and is therefore sought after. Information falling on the informational array from the analyzers will be continually sought to the degree that it stimulates post-information-array activity.

A second factor operating contrary to the first is satiation. Continued excitation of the same neural fibers results in receptor and neural cell fatigue. The experience of boredom derives from a failure of the informational array to produce further imaginal activity either because of satiation or for some other set of reasons which limit the flow of imaginal activity from the informational array.

The progenerative principle whereby the organism seeks further information of the kind it found stimulating and the satiation principle whereby continued stimulation by identical or similar sources tends to be discontinued can be thought to operate in the context of a modified signal detection model. Signal detection theory as applied to the most basic psychophysical situation involves conceptualizing the background cues as noise above which the stimulus is to be received. The stimulus, termed the signal, is thought to have a distribution of subjective strength which must be on the average higher than that of the background stimulation, termed noise, if it is to be received reliably. As shown in the accompanying figure, the distribution of the background noise and that of the signal's strength can be depicted as overlapping normal curves. The distribution of the signal shown to extend further to the right than does the distribution of noise indicates its greater signal intensity. The subject experiencing the situation is required to determine whether a signal has been present or whether it has been absent. To accomplish this task the subject is thought to establish a subjective criterion by which he decides whether or not to acknowledge the presence of a signal. This decision criterion has been shown to be generally independent of the sensitivity of the subject, sensitivity being a measure of his organismic ability to discriminate the signal from the background noise. Thus, with his decision criterion set at position one in the accompanying figure, the subject will never mistake background noise for signal but will frequently fail to recognize the presence of a signal when it is actually there. This is to say in the language of signal detection theory that the subject will make no false alarms but will make a large number of misses. With his criterion for decision set at point two, the subject will make fewer misses, recognizing the presence of the signal more often when it occurs than by setting his decision criterion at point one. However, he will also make more false alarms as shown by the shaded portion of the noise distribution lying to the right of his decision criterion, stating that the signal was present when in reality only noise was present.

Not only does the subject's decision criterion affect the accuracy of his judgments but so also does the actual organismic sensitivity. The organismic sensitivity and the actual physical difference between the signal and the background noise can be conceptualized as creating a larger distance between the noise and the signal distributions shown in the second frame of the accompanying figure. Setting his decision criterion at point 1A so as not


Noise
Signal
Noise
2
1


Noise
Signal
Noise
2
1

to make any false alarms, the subject with greater sensitivity or a subject operating under conditions where the signal is of much greater intensity than the surrounding noise is able to make correct recognitions (hits) on a greater proportion of the signals than in the previous example. Adopting the decision criterion at point 2A, the subject assures himself that he will make almost no misses but in so doing allows for a number of false alarms given by the shaded portion of the noise distribution. However, it is the greater discriminability of the noise from the signal distribution in the second example that allows the subject to achieve a near hundred percent hit rate while allowing only a few false alarms. In the first example, the subject setting his decision criterion at point two to achieve a near perfect hit rate also allows a huge number of false alarms.

This distance between the two distributions of signal and noise is an index of the discriminability of the signal from the noise and has been labeled d' (d prime) within the context of signal detection theory. In the typical psychophysical experiment, the noise distribution is constituted of the background stimuli in the testing session and the subject's internal variability, for example his thinking about something outside of the experiment. Noise is kept to a minimum by informing the subject prior to each time period during which the signal might be presented; the signal is frequently of a barely discernible amplitude. This signal detection model can be applied to a very different type of reception situation by conceptualizing the noise distribution as the material on the informational array of the subject, and the signal distribution as that stimulus or informational unit which potentially may be entered onto the array. Essentially this involves no conceptual extrapolation, the only difference being that in the standard psychophysical situation care is taken to reduce to a minimum the noise distribution (array content) where in the more typical operating situation, the human is typically involved in the active analysis of information other than potential signals. The critical issue then becomes, what are the conditions under which a signal not presently on the array will be selected for array representation? Said more completely within the constructs of the Information-Integration Theory, what are the conditions under which information will either gain access to the informational array or increase its percentage occupancy of the informational array at the expense of information already on the informational array?

The signal detection analysis allows us to expect that under conditions where (1) d' is increased, that is the discriminability between information presently on the informational array and the signal in question is increased or when (2) the decision criterion is lowered, a signal will command increased space on the informational array. Let us consider first the conditions under which changes in the d' will affect the selection of information for the array.

Changes in d'. The d' can be increased either by strengthening the signal or by reducing the noise. The first implies that strong, intense stimuli will have a greater likelihood of gaining access to the informational array than will weaker stimuli, holding constant the contents of the array itself. In the case of loud noises or bright visual stimuli or intense tactual stimuli and the like, this deduction makes intuitive sense. However, the same would be predicted by the theory to hold true for other inputs to the informational array which include feedback from the bodily motor activity, other bodily cues such as respiration, heart rate, as well as thoughts.

The measurement problems here cannot be denied for it is clearly easier to test the prediction that strong sensory stimuli will have a greater likelihood of gaining access to the informational array than weaker sensory stimuli than it is to test the prediction that strong thoughts will have a greater likelihood of penetrating the informational array than will weaker thoughts. The rather obvious problem here is that we lack measurement units for the intensity of these internal events which can be approximated in the case of sensory input by measurement of the physical characteristics of the stimuli applied. Information about bodily states such as hunger or thirst or heart rate have the same measurement problems as thoughts. These examples while also unable to be measured in physical units in the manner possible with sensory stimuli have been rather successfully investigated in the context of other theoretical models (S-R models, for example) by appeal to construct validation. Thus, for example, hunger cues are assumed to increase as the number of hours from eating increases, as a function of the amount of food provided the organism, and so forth. One would hope that the issue of whether thoughts act in the manner suggested by the present theory could be assessed through a similar methodology.

The d' can also be increased by a decrease in strength of the data of the array, the "noise" component with which incoming information is competing. The extreme condition here or nearly approximate to it is the traditional psychophysical experiment where reception of some signal is maximized by minimizing other sensory input and preparing the subject in a comfortable surrounding and informing him of the period during which the signal should arrive in order that he might best prepare himself. Within the constructs of the present theory, this situation is seen as clearing the informational array as much as possible and providing the subject with a set to expect a certain kind of information. Clearing one's informational array in preparation for reception of some future information increases the relative distance between the signal and "noise" (the array content). In addition to reducing the informational array content, the readiness set has two additional functions: one is that given sufficiently specific information as to the nature of the incoming signal, the inhibitory process can actively block input from unwanted sources, and second, the activation of the expected signal on the coded portion of the informational array can facilitate recognition of the raw signal pattern on the uncoded portion of the array. Most critical here though is the notion that the relative absence of material on the informational array increases the likelihood that a potential signal will gain access to the array.

This extreme case where the informational array is cleared maximally constitutes one point on a dimension. This dimension is defined by the degree to which the informational array is filled with data. When undertaking a task which is experienced as interesting and absorbing, the informational array will continue to gather information specifically relevant to the task at hand. This is in line with the progenerative hypothesis that an informational array which elicits further neural activity will continue to be supplied with information to further that activity, i.e., it will continue to select information from the same sources. If, however, the information on the array does not give rise to further neural activity, the organism will be less likely to seek continued information from those sources which will result in the informational array being inadequately filled. This state will be remedied by information coming from other sources, that is other signals will be received. Thus, in the case of simple tasks and in the case of boring tasks, the information array has extra capacity and thus allows for "distractor stimuli"

to gain access to the array. It is for this reason that tasks not perceived to be interesting tend to allow for a great deal of distraction.

A third manner in which d' can be affected and hence change the character of the information which gains access to the array concerns the inhibition process. Recall that reception of any channel of information is made possible by the relative inhibition of other aspects of the organism's environment including the environment constituted of his own feedback and mental activity. Inhibition is the process by which analyzer data are prohibited entry to the informational array. In practice this process is relative; for example, as has been discussed above, in the dichotic listening situation, the processing of information in one channel prohibits the semantic decoding of the information in the other but does not totally obscure the reception of the "unattended to" channel. Rather, very basic information such as the pitch of the unattended to message is registered. In the context of the Information-Integration Theory, it was argued that the array was not large enough to carry the information from both channels but was large enough to carry basic information about the physical characteristics of the "unattended to" signal. Thus, though inhibition is not necessarily capable of eliminating entirely a potential signal from the informational array, the use of inhibition against a certain set of analyzers does have the function of decreasing d' and hence the likelihood that the inhibited signal will gain more space on the array. In decreasing d', inhibition makes the potential signal or even the amount of the given signal already being received less distinguishable from the array content, thus decreasing the likelihood that that signal source will be processed in the immediate future.

In general, the larger d' becomes the more likely it is that the signal will increase its representation on the information array. Inasmuch as cues are not processed as units of analyzer firing but are constituted into channels, it is likely that the signal with a large enough d' to be received initially commands a major portion of the informational array in a rather undifferentiated manner and immediately following, within milliseconds, is constituted into a channel. If the signal source, once constituted into a channel, does not have signal value for the organism, that is if it does not stimulate further neural activity, processing of the source will be discontinued in favor of new input.

Change in decision criteria. Changes in the specific content of information processed at any moment (changes in attention deployment) are also dependent upon the decision criteria the subject imposes on incoming signals. Even though a certain type of information may normally be allotted some small proportion of the array, as for example is our kinesthetic information alloted sufficient space for coordinated motor activity, the decision criterion specifies the degree of signal uniqueness sufficient to cause the organism to form a central channel around that signal. Signals of an intensity falling below the decision criterion will not cause the organism to form a channel around the signal. Rather, the information in that signal will continue to be utilized in a manner as before unless some other signal source demands some portion of the informational array carrying the initial signal in question. Then, the initial signal source can lose part of its even small representation on the array. For example, some small change in the ambient sound level of the room will not be sufficient (will fall below the decision criterion) for the organism to form a channel to process the sound source further even though the ambient sound level is being registered. Further, if a particularly striking thought,

body sensation, or other sensory input occurs, it may require that the organism retract some of the small amount of array space allocated to the sensing of the ambient sound level in the room in order to register adequately the central information.

If a signal is of greater intensity than the criterion, a channel will be formed surrounding that signal and it will command considerable space on the informational array. As this change in array content is taking place, d' for other signal sources is greatly reduced, making the organism very insensitive to new input of any kind. Once the channel has been constituted, the d' for other signal sources will be re-established according to the parameters discussed above. In addition, the new processing situation may bring about changes in the decision criteria assigned to the reception of new input from the various signal sources.

The rules governing decision criteria are extremely important for any theory which seeks to explain the sequence of information processing (attention deployment). At any point in time depending on the array content, the behaving organism adjusts the decision criteria for reception of information from the various analyzer and analyzer combinations. For example, decision criteria can be adjusted up so that increased signal strength will not be sufficient to require the organism to form a central channel around the input source. Take a specific example such as sitting down. Increased processing of visual, tactile, and kinesthetic information is required; but one need not form a central channel around these sources to execute this simple behavior. Instead, one can raise decision criteria for these sources and simply give over more of the array to them which will occur automatically as the organism begins to sit as long as he does not try to inhibit these data. As he sits, the person can continue his conversation or other ongoing activity though it may proceed haltingly as the informational demands from the visual, tactile, and kinesthetic sources usurp greater amounts of the array space. If, even after raising the decision criteria for visual, tactile, and kinesthetic sources, a signal is registered which deviates sufficiently from the immediately previous array data that it falls above the criterion, then a channel will be formed around the source and the ongoing activity such as the conversation will be replaced. Such could occur if one notices an object on the chair, brushes against the arm of the chair, finds the chair harder or softer than allowed by the tactile decision criterion, and so forth.

The central point is that the organism sets as a function of the information on the array decision criteria for the reception of information for various analyzer combinations. As long as the stimulation falls below these criteria, it is processed in the amount allowed by the workings of the inhibition system which selects and defines the channel being processed. Information falling above the decision criterion requires the organism to reconstitute its central channel surrounding the stimulation in question.

Processing of any material will thus continue with the channel as constituted until either (a) a signal sufficiently different from that being processed which is above the decision criterion set by the organism is received; (b) a signal source insufficiently inhibited transmits data which though below criterion are sufficiently information-laden to upset the ongoing channel by leaving it with insufficient array space to represent its data. The person in these cases will experience losing his "train of thought" without some

other signal source "taking over"; (c) the neural activity stimulated by the informational array declines in frequency to the point where further information-gathering from the source supplying the array is discontinued; (d) satiation occurs; in both (c) and (d), the reduction of array information directly increases d' and lowers decision criteria thereby increasing the probability that some new signal will be of sufficient relative strength to gain representation on the array; (e) some subset of the information in the central channel is sufficiently deviant to provoke a more defined channel involving that informational set. This is a special case of (a) where the signal source for the new channel exists within rather than outside of the original channel; (f) a (learned) thought is evoked which instructs the organism to alter its processing. Self-instruction thoughts such as "what was I doing?" or "pay attention!" or "concentrate!" are conceived of as feedback from rehearsal onto the coded array. These thoughts have typically low decision criteria, thus allowing their frequent use in constituting new channels. They are aroused in somewhat different situations for different people depending on one's training but in general when the central-channel information is not relevant to the idea represented on the coded array about the task at hand. By maintaining ("keeping in mind") a notion of one's task, one can learn to respond with self-admonishment whenever the central channel content evokes post-array activity more discrepant than a set criterion than that deemed relevant to the task. The role of the coded array in directing information processing is considered immediately below.

Special role of the coded array in direction information processing. The coded portion of the informational array plays an important role in maintaining what is called "directed attention" i.e., processing of a given channel once constituted. By virtue of its relatively great stability, the coded portion of the informational array is first able to assure that the array will have content in it and, hence, not be vulnerable to outside "distraction." Recall that the more usurped the array is, the smaller will be the d' between extraneous signals and the array content. Consequently, extraneous signals would have a lower likelihood of gaining entrance to the array. Second, for the same reasons, the rehearsal capability of the coded array provides further stability. Third, the coded array can represent verbal instructions and self-induced sets which direct the coding of information received by the uncoded portions of the array, thereby increasing its signal life. This coding and the subsequent imaginal and motor activity resulting from it facilitates the maintenance of the established channel. Fourth, at least for the mature human organism, the inhibition process which constitutes channels is heavily directed by information of a semantic variety. Though it is possible within the model for uncoded information to direct channel constitution, as for example when an unusual sight causes us to examine carefully, it is likely more frequently the case that symbolic mediation is instrumental in constructing further channels and as such in directing the inhibition process. This function of the coded array is familiar to anyone who has tried to "direct the attention" (schedule the information processing) of a pre-verbal or severely intellectually retarded child or an infra-human organism. Directing the attention of another organism without verbal means is very difficult. As Luria (1961) has shown, gaining verbal direction over one's behavior is a developmental achievement. A minor extension of this thinking suggests that the human develops verbal control over much of his information selection by self-instructions on the coded portion of its informational array. The educational ramifications of this conceptualization are obvious.

The coded portion of the informational array has one additional function which serves to direct information processing. The disruption of a channel by any of the above-mentioned means naturally leads to the constitution of a new channel. However, our immediate experience does not appear seriated into successive channels; instead, we are guided by a conception of a central task, however many times we are "interrupted" by shifts in the specific information being processed. Even when task-irrelevant information has signal value and becomes constituted into a channel, the person is typically able to resume his original task.

The simplest explanation as to why the organism can return to the original task is that a sufficient portion of the information concerned with the task is still available on the array or continues to be supplied by the environment. This explanation fails for distractions longer than 15 seconds (the coded array's approximate signal life), particularly when the original task is entirely mental. Thus, unless some representation of the original task is maintained throughout the distraction period, some additional mechanism is needed to explain how the organism knows it has been distracted.

The difficulty is in explaining how a person totally distracted from his task (1) knows he was distracted and so does not proceed "aimlessly" and (2) can remember what the central task was in order to resume it. It is the first portion that presents problems. One cannot simply assume that the external stimulus environment will cue the appropriate behavior again once the distractor channel has satiated. Such a fortuitous mechanism is not consistent with the directed, purposive behavior humans exhibit. Further, adults, and perhaps children, are able to return to strictly mental tasks after being distracted even though there are no external cues with which to reconstitute the old channel.

One simple initial assumption is that if no representation of the original task remains on the informational array and no environmental cues are present to cue the behavior, then the distractor information will have to be removed by one of the previously listed procedures, e.g., satiation, competition by other signals, etc. As the array becomes available, the organism is left with the problem of returning to the original task.

The information-integration theory posits a hierarchy of informational inputs which was described previously as varying from person to person and within each person from situation to situation. Part of cognitive development entails utilizing one's own mentation, increasing its probability of selection as an input. Even if distracted for a period of time sufficient to remove totally from the coded array any recollection of the central task, the human is trained to utilize mentation regularly to guide his behavior ("to know what you're doing"). Hence, an adult will typically process his own mentation after a distraction, sometimes even using specific verbal prompts such as "Now where was I." Such an orientation "inward" for direction removes one from the vagaries of the external stimulus environment.

The Theory need additionally account for the presence of the central task ideation when the mentation source is sampled. Why of all possible thoughts does the person select those relating to the original task?

It must be recognized that the person does not, in fact, always select the appropriate information from thought that will return him to the original

task. People do get side tracked; many tasks never get finished. However, more typically at least in the short run, processing of the mentation source supplies the information with which to resume the original task. While at times it is necessary to add a self-instruction like "What was I just doing?" or "Where was I?", such instances do not seem different in kind from a time-linked access of memory requesting a statement of the organism's recent activities which also have the character of importance to the organism i.e., a central task. There is considerable evidence that humans code time as part of their experience as demonstrated most convincingly by the research on judgment of recency (cf., Hinrichs, 1968). The present theory's integrational emphasis can readily account for why recency and importance to the organism can serve as retrieval cues as these were integrated with other aspects of the experience being sought from memory.

The explicit or implicit use of temporal retrieval cues may not entirely satisfy the issue of how a person can remember what he was doing prior to being distracted. People speak of having something "on their mind" or say they want to "sleep on it" or experience thoughts as intrusively seeking expression as when one is troubled by an important problem or upon experiencing a difficult situation will say "I can't get it out of my mind". These expressions all imply that there might exist neural activity in the imaginal system which exists far longer than material on either the uncoded or coded array. Without going into great detail here, I would assert that input from mentation may be inadequately conceived of as information in data bins with various retrieval tags (e.g., Yntema & Trask, 1963) but plays a more active role in becoming expressed on the informational array. The signal life of neural activity in the imaginal system may simply be longer than that on the array. Alternatively, or perhaps additionally, some imaginal activity may be stimulated by such a wide variety of cue conditions or omnipresent cue conditions such as the person's own bodily state that they are active considerably often.

Returning to the immediate question of how the distracted person can remember the original task once he has chosen to process his mentation source, we arrive at a somewhat different explanation. Instead of postulating that the person utilizes temporal retrieval tags, he may simply have the central task more available by virtue of it still being more active in the imaginal system than is older material. This explanation has the disadvantage of requiring the postulation of a signal life for imaginal activity that is different from the representation of the same material on the coded informational array but has the advantage that it meets with immediate experience and suggests many interesting questions about the workings of thought. Obviously, this issue deserves careful study.

Summary. The coded portion of the informational array is critically important in directing information processing and, in so doing, maintaining continuity in mental and motoric activity. The long signal life of coded array material and the coded array's rehearsal capability provide stability by keeping the array active and, hence, less accessible to task-irrelevant information. The coded array also can represent self-induced sets and instructions which aid in the coding of raw analyzer data, thereby increasing their signal life which in turn provides processing stability. Instructions on the coded array also serve to direct the inhibitory processes in a manner analogous to when one requests of another that he "watch carefully". Such instructions serve as

cues for the inhibitory system, particularly necessary in novel situations. (They would be expected to become redundant with the external cues in practiced situations and would likely drop out inasmuch as they require productive effort.) Finally, the coded array is instrumental in the organism's recognition that he has been distracted from his original task and in returning processing to the original task. Either by retrieving recent-important events or by aspects of the original task still being active in the imaginal system, the coded array aids in reestablishing the processing of the original task's information.

Role of Anxiety

The function of anxiety has played a central role in theories as diverse as Psychoanalysis and Hull-Spence Drive Theory. The concept's absence in information-processing models constitutes an oversight not satisfied by appealing to the so-called cognitive nature of these models. It is the view of the Information-Integration Theory that behavior must be conceptualized broadly enough to provide at least minimal bridging between areas of thought. Cognitive psychology has been particularly isolationistic, its often cited survey text (Neisser's Cognitive Psychology) containing not a single subject index reference to anxiety, drive or motivation.

A central issue in the experimental literature on anxiety which has stimulated two decades of research concerns whether anxiety's influence acts through drive level or cue base variation. The drive position of Spence (1958) has argued that emotionality acts through changes in drive (D) and that performance on learning and performance tasks is predictable from the hypothesized multiplicative relationship between D and habit (H).

The opposing position, well articulated by Child (1954), holds that anxiety adds new stimuli to the organism's immediate cue base, thereby modifying his performance through changes in the habit component of behavior.

It would be glib to assert that voluminous research supports both positions as such is usually the case when opposing theories square off on a specific issue. Nevertheless, I have always felt that viewing the drive and habit interpretations of anxiety as disjunctive represents a dysfunctional slavishness to Occum's razor.

The phenomenon of anxiety is a complicated one within the Information-Integration Theory. Though parsimony is not served, the complex phenomenon of anxiety may be more accurately represented than by the unitary action posited by the drive and response interference (habit) positions.

A wide variety of events can come to stimulate patterns of activity within the autonomic nervous system. The prototypic cues are intense, unexpected, noxious sensory signals such as loud noises, rapid movement, and the like. The defensive response (DR) elicited by cues of this type is characteristic of that which can come to be evoked by informational content which the organism perceives as threatening (Sokolov, 1960). Without dwelling on the issues surrounding how content can come to be noxious to the organism, let us consider the effects such signals will have on information processing within the context of the Information-Integration Theory.

Two aspects of the processing system will be affected, the inhibition process and the array content. Inhibition will be affected by changes in reticular activating system (RAS) stimulation produced either directly as part of the stress reaction or secondarily by feedback from the body's response to stress, for example, by kinesthetic feedback from muscular tension. (The reader familiar with the Spence Drive Theory literature will recognize that this feedback mechanism was frequently utilized as a drive manipulation by having the subject vary muscular force he applied to a dynamometer.) Increase in RAS activity provides more energy for the inhibitory mechanism, greater arousal resulting in more selectivity and, hence, narrower channels (cf. Easterbrook, 1959; Silverman, 1964). The extreme of this condition can be dysfunctional, especially on complex tasks which require processing of information from a wide variety of analyzers and/or input sources. Thus, increased arousal will be facilatory if the task involves information processing over narrowly defined channels but will become increasingly dysfunctional if the heightened inhibition forces channel definition too narrow for the integrational demands of the task. This conceptualization may provide new insights into the interaction frequently found between arousal (drive) and task difficulty (complexity). In the very extreme state, inhibition will gate aspects of the environment that might prove useful for adjustive behavior (cf. Broen, 1969).

The second locus affected by the elicitation of autonomic nervous system activity is the informational array. The primary affect is the processing demand resulting from the increased bodily cues. The information deriving from changes in heart rate, respiration, muscular tension, and the like is costly in that it either must be processed or inhibited. Its intensity suggests that at least some of the information will reach the array. If the signals are of sufficient strength to fall above the organism's decision criteria, his central channel will be reconstituted around the intrusive signal as, for example, when one is startled by a sudden movement in the dark. Often, however, the organism will learn to anticipate anxious situations so that in setting his decision criteria for bodily cues high, he will not be interrupted by them. The cues will still represent a processing demand, however.

These bodily cues have a secondary effect as well. Information on the uncoded array may give rise to labeling (coded array representation) and/or post-array imaginal and/or motoric activity. The nature of the post-array activity will vary from person to person depending on his integrational history. Typically, intense bodily cues evoke interpretive cognitive activity. Consistent with Schachter's theory of emotion (1964), the Information-Integration Theory recognizes that the post-array imaginal activity will be a function not only of the discrete pattern of bodily cues, which may not in and of themselves be sufficient to discriminate between emotional states, but also of the information simultaneously derived from the environment (sensory analyzers) and its interpretation (mentation). Different emotions (coded array labels and post-array imaginal and motoric activity) may derive from similar bodily states accompanied by different situational information derived from the senses and mentation.

In addition to the imaginal activity, motoric activity may flow from the information on the array. Typically, avoidance behavior is initiated wherever possible. The execution of the avoidance behavior and the kinesthetic feedback from it place further demands on the informational array.

The informational array need be thought of as fluid, entertaining information from the bodily state, from the labeling of these states, from the external environment, and from the feedback sources of mentation and kinesthesis. Termination or suspension of the emotional state will result from either (1) when the instigating source is removed and the bodily and mental activity fail mutually to restimulate each other, (2) when the organism removes itself from the stimulating conditions and the derivative activity as above fails to be restimulated, or (3) when one of the information sources responsible for maintaining the state satiates. Note that it is possible within this Theory for the emotional activity to persist or be reinstated long after the instigating source is removed. The bodily state and the mentation system can mutually provide the necessary array cues to evoke activity in the other. This positive feedback loop is particularly likely when arousal is pathologically high such that sensory input that could provide information disconfirming the appropriateness of the emotional state is inhibited from entering the array.

The demands on the information processing system from bodily states, mentation, and to some extent from the execution of motoric behavior and its attendant kinesthetic feedback detract from the total capacity available for other processing activities. The reduction of available capacity together with the indiscriminate narrowing of channels under extremely high arousal states interferes with performance on intellectual tasks, especially those requiring extensive array space and broad channels formed from multiple sources.

SUMMARY

The Information-Integration Theory seeks an understanding of the laws governing how the organism selects information, and integrates it with other information being input from both the external environment and the organism's internal environment including his bodily sensations, stored memories, and feedback from his motor behavior, and mental reactions to events. The Theory conceives of information as a pattern of neural activity composed of a plethora of unit data. Some patterns require more units of information than others for understanding to result and, hence, demand more of the organism's limited capacity. Linguistic materials are characterized by demanding considerable array space. Entrance of information onto the array is modulated by an inhibitory process wording in conjunction with the organism's discriminative sensitivity which admit information for processing if it deviates significantly from that occupying the array. Inhibition can be applied to specific inputs to make them less discriminable thereby limit their processing. Uninhibited material constitutes the central processing channel, by the hierarchical organization of unit data throughout the organism's development. Signals still deviant from the array data, once any inhibitory force has been taken into account, will cause him to discontinue processing the ongoing information-channel in favor of processing further in deviant input. Decision criteria and the inhibition process are directed by the information on the array and, hence, are situation-specific.

Information enters the array in parallel until the array capacity is reached, input being received from sensory input, bodily states such as heart rate and hunger, feedback from motoric activity, and mentation. The continued input registered from these sources, particularly from motor and mental feedback,

provide exceptional continuity to the organism's array content which constitutes his immediate cue base off of which further behavior is generated.

The information on the array can be distinguished by its signal life, raw data from the sensory analyzers, from kinesthetic feedback, and from other bodily sources, having a very brief life; coded material such as linguistically coded input, thought and visual imagery has a life span as much as 15 times longer. In addition to longer signal life, coded material also has the advantage of being extremely efficient by representing only the most critical aspects of the event and by being regenerable, either as productive thought or as rehearsal of information already on the coded portion of the array. The efficiency and regenerability of the coded material add immeasureably to the processing power of the system.

By virtue of the varied information simultaneously available to the organism and his tendency to respond to broad patterns of neural activity, many contemporaneousaspects of an event will be integrated into a single recollection. The resulting multi-dimensionality of memories significantly aids their retrieval at a later time and their stimulation by similar neural patterns of information to take on new meaning by association with other coexisting patterns. This process requires that one of the repetitive neural patterns on the informational array first be capable of exciting post-array neural activity either in the form of efferent or mental (imagery or thought) activity. The post-array neural activity constitutes the meaning of an event. Integration is a process by which a novel, repeating pattern of neural activity on the array contemporaneous with a known pattern comes to evoke similar post-array neural activity, the post-array activity resulting from their contemporaneous airing on the array results in unique (creative) thoughts. Integration is limited by array size which restricts the amount of information that can be simultaneously displayed.

Stimulation of post-array activity is critical if the organism is to continue processing a given information source. The progenerative hypothesis formalizing this assertion states that an informational source whose input stimulates the motor or imaginal systems will be sought after while a source whose input fails to be stimulating will come to occupy a lower position in the organism's information-selection hierarchy and, hence, be less frequently selected.

The organism's output (motoric behavior of speech and the musculature) is organized and monitored through feedback by the informational array and, hence, draws upon the same limited capacity as does information reception and integration. Dependence on feedback to generate further behavior is noted when disruption of the feedback occurs as in sensory deprivation, delayed auditory feedback, and anaesthesia.

The selection of information and its integration in the service of stimulating motoric and mental activity is not just one task but is the task the organism engages in to bring about his adjustment to his external and internal environment. Idiosyncrasies in the structural of functional characteristics of the system together with the specific information encountered serve to mold a unique organism. Educational disabilities, described in the following section, derive from these idiosyncrasies, particularly from disorders within the information-integration system.

APPLICATION OF THE INFORMATION-INTEGRATION THEORY TO READING ACQUISITION AND READING DISABILITY

In this second major section, the Information-Integration Theory will be used to conceptualize the problems of children having school difficulties. I shall first consider a few general problems about the application of the theory to educational difficulties, particularly those problems concerned with the use of categories (diagnosis). Then, the Information-Integration Theory is used to generate a model of normal reading acquisition. Next, I consider the construct of "short attention span" solely in terms of receptor orienting acts, that is in terms of the physical orientation of the receptors as opposed to the internal selection of information. Following this discussion of attention span, problems in reading are discussed by describing the various possible process deficiencies which could mediate reading failure and the theoretical syndrome pictures that would be expected from the Information-Integration Model.

THE ISSUE OF CATEGORIZATION (DIAGNOSIS)

There appears to exist a trend today in special education away from categorizing in favor of a treatment of each child as an individual. Through the use of specific diagnostic tests, it is thought that a unique remedial program can be instituted for each child provided that the necessary resources are available. Thus, no need is seen for first classifying the child into a specific disability type. The argument follows that having the child classified as a specific disability type does not aid in the construction of the remedial program nor does it yield additional information about the child's disability as would be required of a useful category-classification system. Consequently, the process of classifying children into types has been discredited. Whether or not one chooses to classify using a category system depends heavily on the uses to which one would put the resulting information and whether for those purposes the system of classification is valid (Zigler & Phillips, 1961). There are a number of basic questions concerning categorization that I would like to comment on, though no attempt will be made to treat these issues in detail. The first is why one should or should not categorize. In these following remarks I am thinking specifically about the area of special education although they equally apply to other areas where deviant behavior is under consideration. There are many reasons arguing for a categorization process as there are many arguing against it. The issue should not be resolved as to whether everyone at all times and for all purposes should or should not use a categorization procedure but rather whether for a given purpose at a given time the virtues of categorization outweigh the attendant problems.

The benefits of categorization. Arguing in favor of the categorization process are the following reasons: First, categories serve a large number of administrative and budgetary functions. From Federal Government programs down to the operating of a single classroom, the distribution of resources, the administration of programs, and the accounting and record-keeping procedures are all highly dependent on some category system. Secondly, category labels serve many sociological functions, as for example allowing for the creation of ACLD and other similar organizations which can use the diagnostic labels as a source of their group's cohesiveness and the basis of their interest group. These groups in turn serve other functions, in particular the individual needs of the group members. Third, labels (category names) serve as a communicative shorthand for persons working in the area. As a shorthand, the labels may be no more than descriptive but do provide a simple and direct manner of communication. Besides serving as a communicative shorthand, labels should yield

additional information. Details about the child one loses in categorization should be offset by gaining knowledge in the form of established correlates of the category classes. Thus, for example, the use of the term Trainable Mental Retarded as opposed to Educable Mental Retarded makes a number of statements about the type of remedial program that is appropriate for a child diagnosed as either of these two categories. The category label carries with it a prediction as to the child's ability to function in a certain remedial setting and to gain from it. This represents just one of the many correlates one would hope all category classes would carry with them.

One final benefit of category systems relates to the notion that categorization yields additional information through the class having established correlates. This is that categories form the basis of a research approach which seeks correlates to established classes. Our major research methodology in studying deviance has been to establish a class of deviant behavior and then to study how persons in that class differ from those designated as normal. The very logic of this approach requires the presence of well-defined classes such that persons can be reliably assigned to those classes on the basis of the class principles and then research can study persons reliably assigned to the class to find out other important aspects of their functioning (class correlates) which may then relate to prevention, management, remediation, and prognosis. The total abandonment of classes would mean the necessary abandonment of this research approach, and it is not clear what means of expanding knowledge of deviant behavior would take its place.

The dangers of categorization. At the same time there are many reasons why category systems should not be used. These include the possibility and often the likelihood that the person labeled will become stigmatized. Though being labeled "learning disabled" may bring additional resources to a child's aid, the label itself may constitute for the child a personal problem in addition to the disability itself. Secondly, diagnosis, as a process of putting persons into category classes, is costly. A good deal of professional time and energy as well as the child's time is expended. One could argue whether this time and energy could be put to better use in a remedial effort. Third, error in diagnosis which labels a child as deviant, when he may not be, can exacerbate a minor adjustment problem the child is having or even create one. We know from research that teacher and parent expectations are important forces in a child's life. Being labeled and being acted towards by significant adults as deviant can serve as a stimulus for deviance itself. Finally, the creation of classes and the use of these labels can reify our own thinking, making us believe in the existence of types of problems which may only exist in the mind of the observer. Continued usage of labels tends to become self-perpetuating as, for example, our over-use today of the hyperkinetic diagnosis. By failing to specify clearly the class principles by which the hyperkinetic diagnosis is to be applied, we have allowed for the gross over-use of the term and the subsequent administration of drugs to a huge population of children. The very over-use of the diagnosis and the subsequent drug treatment themselves tend to perpetuate the use of the term and our belief in the existence of such a disease entity.

The reasons for and against categorizing given above could certainly be expanded. The main point I am trying to make here though is that whether or not one categorizes is based on a whole host of considerations. Whether or not one overtly utilizes a category system should be determined through a

careful consideration of the available systems and the value and costs of applying them. Through such a procedure a practitioner in one setting may decide it is not to his advantage to engage in a lengthy diagnostic venture where another practitioner in a different setting with different resources may make the opposite decision. Further, the researcher may require that the subjects of his research be carefully categorized. In no case, however, should it be sufficient that one not categorize because dispensing with category labels is presently fadish.

Categorization as inevitable. The second major point to be made about categorization is that it occurs whether or not one formally uses a category system. The very language system that we use is essentially a categorization process whereby a host of behaviors becomes subsumed under a single work. For example, describing a child as impulsive is in a sense a category label used to describe many different behaviors which have in common some abstract characteristic, noted by the meaning of the word impulsive. I would claim also that the process of classification goes on naturally to a further extent in that the virtue of experience is in part the noting of regularities and applying to subsequent cases the knowledge gained from previous ones that appear to have been similar. The very notion that we are able to talk of two children as having a similar problem substantiates the existence of an implicit category system. Though it is laudable to approach each child as an individual, one should not mistake this philosophical stance with the goals of a remedial technology. One can approach a child as though he were an individual person with whom one is concerned while using knowledge gained from helping children with similar problems just as a good physician will make his patient feel like an individual and of individual concern to him even though he is treating a disorder which is routine in his experience. The fact that there is order and patterning in educational disabilities is not the dehumanizing force in education, anymore than it is the existence of diseases which make the medical profession appear inhuman in their treatment procedures at times. The knowledge gained by the careful study of diseases is to the benefit of those who in the future contract those diseases. Similarly, a careful study of the various educational disabilities is required for the construction of appropriate remedial programs and hopefully, at some point, preventive programs. The benefits of individualized instruction should be applied in conjunction with knowledge about the child's disability, not instead of it.

The need for useful categories. If my contention is correct that categorization goes on implicitly, the real issue would seem to be whether the categories which are researched are those which the practitioner uses, and whether either the categories used by the researcher or those of the practitioner have validity. The general dissatisfaction with categorizing, that is with the diagnostic enterprise, to my mind springs from the disjunction between the level of knowledge required by the practitioner and that produced by the categorization process. It is a routine event to have a child sent to a clinic because he is failing in school only to have him diagnosed as a "learning disability" case. Is it any wonder that the referring teacher has no patience for this type of diagnostic effort? I would claim that what is needed is not less diagnosis but a better one. In essence, our diagnostic systems are geared to very broad categorization. For example, we distinguish between mental retardation and learning disabilities. The practitioner, usually specializing in one of these two areas, is more concerned about distinctions

within each group than those between the two groups. Consequently, a diagnosis which involves solely the use of one of those two labels is not at all helpful. It is for this reason that the so-called reading diagnostic tests and other basic skill diagnostic tests have gained so in popularity. They attempt to describe the functioning of individual subskills and hence provide the teacher with useful information about each pupil. Were there a diagnostic system which described the functioning of the child which was relevant to the teacher's intervention program such that classification of the child dictated a certain optimal program validated by evaluation research, the teacher would likely accept such a system. Thus, it would appear that the problem with our present diagnosis is that it is simply not useful. It is the fault not of the logic of categorization but the level at which categorization has proceeded in the field of special education.

Categories as various adjustments to disability. A final consideration concerning the use of categories is the issue of what the categories one uses actually represent; are the categories discrete entities as they are typically thought to be within a medical orientation? Or are we dealing with continuous dimensions which we divide into discrete categories rather arbitrarily as, for example, the distinction between the trainable and educable retarded child where presumably there is a simple quantitative difference between the intellectual skills of children in each of the two categories?

In the first case, that of diseases, the basis for categorization is thought to be truly dichotomous, one either having or not having a given pathological characteristic. This thinking, however, is likely deceptively simple even within the medical context where the applicability of this approach is more sound for infectious diseases but loses its clarity when applied to systemic diseases. Whereas one can test for the presence of an infectious agent and state at a given level of confidence whether it is present in some degree or entirely absent, one has a different problem in determining how much systemic malfunction one will tolerate prior to imposing a disease label. For example, how much sugar in the urine will one tolerate prior to diagnosing the condition as diabetes. In fact, the recognition that health and disease are not dichotomous has led many physicians to a unified theory of disease. This conceptualizes disease in terms of the total functioning of the individual. A disease within this system is not a specific entity apart from the person but is a part of the person's total adjustment pattern.

This approach has ramifications for special education. In fact, the approach of the special educator in attempting to treat the whole child and not a single disorder is consistent with this way of thinking. The physician treating a diabetic patient within this framework would be concerned with the total adjustment of the individual to the specific disorder and would be cognizant of the fact that the person's total adjustment is altered by the presence of malfunction within a relatively circumscribed system. Similarly, the educational specialist need recognize not only that he treat the entire individual but also that he requires specific, detailed understanding of the various processes which can malfunction. The unified theory of disease does suggest an abandonment of one's understanding of one's research into specific infectious or systemic disorders but rather that one expand one's concern for these disorders by placing them in the context of the total adjustment pattern of the organism. Similarly, in special education, we need an understanding of the specific disabilities encountered by LD children even though we tend to cast

these disorders appropriately, I think, in terms of the child's total socio-educational adjustment.

There is one additional parallel in special education suggested by the unified theory of disease. Diseases are best not conceptualized as present or absent but rather in terms of the degree of severity as measured by their total impact on the organism's functioning. One person with a viral infection, for example, will have severe respiratory involvement but otherwise will be unaffected and be able to carry on pretty much as usual, while another, similarly infected and having an equally severe respiratory reaction will also respond with a gastro-intestinal disorder and be nearly incapacitated. Analogously, the degree of severity of a process disorder may not be the best predictor of the total educational functioning. Rather, we need to examine the wide range of functioning relevant to success in school and examine the child's pattern of functioning and not simply an independent assessment of various subskills.

Within the context of the present theory described in the first section of this paper, the task would be to pinpoint areas where disabled functioning might have ramifications for the total adjustment to the educational enterprise. A type of disorder or category of disability would not be thought of as constituting a specific type of individual discreetly different from all other individuals, but rather would constitute a core problem to which the total system must adjust. Disability is conceptualized in terms of a specific problem in some area of information processing and the subsequent adjustment of the person to that disability. Deviant functioning is to be understood in the same theoretical context as in normal functioning with the exception that some specific area of functioning presents a problem to which the whole information processing and integration system must adjust. Processes dependent upon the disabled process for their proper functioning will show disorder while other processes may be called upon to provide extra service in order to compensate for the disability. To understand these complexities, one clearly needs a testable theory specifying the relationships between a finite set of processes such that patterns of disabled functioning can be discerned and potentially validated.

The section on receptor orienting acts which follows the theory of normal reading acquisition illustrates the dependence of even the simplest overt attending behavior on the total functioning information-integration system. The main thesis of this section is that global terms like "short attention span" fail to recognize the interdependence of this behavior on the total information-processing system. A short attention span, it is argued, can have many meanings depending upon the specific situation in which it occurs and on the other disabled processes with which it occurs.

THEORY OF NORMAL READING ACQUISITION

Understanding reading disability would best proceed through an understanding of normal reading development. We need a substantiated theory of reading acquisition within which disabled functioning can be understood. The Information-Integration theory laid down in the first section of this paper provides the basis of a theory of reading acquisition. The theory of normal reading acquisition which follows is somewhat sketchy, concentrating its focus on a delineation of the processes important for normal reading. To be fully complete,

the theory would need to cast those processes in a development context, specifying the sequence of developmental skills and the level of skill acquisition necessary for adequate reading behavior. The theory laid down in the previous section, while heavily concerned with process rather than structure, is not specifically developmental in nature. However, the theory of normal reading, does provide an adequate framework to describe the various possible types of difficulty encountered by the learning disabled child.

Receptor Orienting Acts

The most basic requirement for a child's learning to read is that he orient his eyes toward the printed page. Though obvious, this widely recognized point has led to considerable misunderstanding in the field of special education. Children who fail to look at their schoolwork are frequently labeled as having "short attention spans". Such a term implies that the child's failure to attend behaviorally is evidence for some underlying process deficit, namely, that his attention span is pathologically short. I believe a construct of this variety is terribly misleading, so much so that I have devoted a section of the paper to a discussion of receptor orienting acts. In this section, I describe how such a term as "short attetnion span" obscures important aspects of the overt behavior which once recognized would yield a better understanding of the inattention toward the printed page. As these issues will be discussed below, at this point it is only important to recognize the obvious fact that for appropriate reading acquisition, the child must possess adequate, overt attending behavior.

Analyzer Integrity

Given that the child orients his eyes towards the page, his visual analyzers must be capable of transmitting the graphic information to his informational array. The critical analyzers, those which together yield information about form, must be structurally intact and functioning properly. Just as visual acuity is limited by the accommodation of the eyes' lens, so too is the ability to discriminate form (graphemes) limited by the neural data provided by the relevant analyzers.

Structural integrity. There are essentially two major reasons for analyzer failure, one structural and the other functional. Though research on analyzers is in its infancy, we do know that specific neural and receptor cells and combinations of those cells are differentially responsive to unique aspects of the stimulus environment. It is logically possible that there exist structural defects in the neural cell combinations which form basic analyzers just as there exist known organic defects in sensory receptors and other bodily organs. Some degree of structural integrity of those analyzers [illegible] for form discrimination would logically be a necessary requirement for reading. (When I speak of reading here, I mean reading with the eyes, acknowledging the obvious exception that unsighted persons are able "to read" using the Braille method).

Structural integrity includes the notion of adequate signal life. The analyzer output to the informational array would be required to have neither too long nor too short a life-span for normal reading acquisition to occur.

Signal life that is too short would require repeated receptor orienting acts to the printed graphemes to enable their analysis whereas an overly extended signal life could cause interference with subsequent analyzer output. Optimally, the analyzer output to the array responsible for form discrimination should decay in the time period between saccatic eye movements. The eye should fall upon a specific set of graphemes, have the analyzers responsible for form discrimination transmit data to the informational array, have this information utilized and decay while the eye moves to the next pattern of graphemes which then begins the cycle anew.

Functional integrity. The analyzers responsible for providing information about form must have functional as well as structural integrity. They must actually provide the information to the informational array if reading is to proceed normally. The progenerative hypothesis of the Information-Integration provides the basis for improvement with practice in reading as well as for an understanding of some reading disabilities. This hypothesis states that neural activity which evokes further neural activity will be continued but that neural activity which fails to evoke further neural activity will be discontinued. As reading develops normally, the beginning reader becomes increasingly capable of having the graphic symbols represented as form analyzer patterns on his informational array generate neural activity in the imaginal system (meaning and associations). The flow of neural activity from the informational array (experienced as thought or imagery) constitutes the major condition for increasing the likelihood that the form analyzers will transmit their data to the informational array in the future. Thus, the more successful the child is in extracting the meaning from the graphic symbols, the more attuned he will become to selecting form analyzer information to occupy informational-array space. This postulate that the accuracy of perceptual form judgments will increase without informative feedback has been demonstrated by Munsinger and Kessen (1965). If the meaning does not readily flow from the visual information on the informational array, the progenerative hypothesis would work in the reverse fashion lessening the likelihood that form information would be transmitted in the future, thus making reading increasingly difficult as the child ages. This point will be returned to below when considering the specific reading disabilities.

Appropriate Channel Formation

Up to this point there is nothing particularly surprising about the prerequisite skills postulated for normal reading acquisition, the only unique aspects of this theory being that it is couched in the language of the Information-Integration Theory. The theory does have two particularly unique aspects to it, however, one being concerned with the requisite information necessary for the reading process and its use and the second being concerned with the critical role played by the mental activity stimulated by the information on the informational array. These two issues shall be considered in turn.

The most central basic process in normal reading acquisition involves the simultaneous processing of a set of one or more graphemes together with the neural equivalent on the coded informational array of the associated phoneme pattern. Reading acquisition is thus viewed as an integration process whereby the pattern of neural activity which represents the graphic forms on the informational array must occur simultaneously with the neural activity representing

the spoken phoneme pattern. According to the Information-Integration Theory, two sets of information must be simultaneously registered, or nearly so, for integration to occur. Integration constitutes the process whereby the mental activity which flows from the phoneme pattern comes to be evoked in the presence of the grapheme pattern.

The phoneme pattern does not exist as part of the reading situation; the child must produce it. Producing the neural activity representing the phoneme may be accomplished either by "imagining" it or by actually saying it out loud; both of these procedures constitute a representation of the phoneme pattern on the coded portion of the informational array, the difference between the two being that the latter, speaking out loud, allows the neural representation on the coded portion of the informational array to evoke the motor behavior necessary for saying the sound out loud, while the former allows only the mental activity (the meaning of the phoneme and its associations) to be evoked.

In order for the meaning, the associations, and the speech sounds corresponding to a phoneme to be evoked by a grapheme, that is for the integration of spoken and written language to occur, three subsidiary processes are necessary: (1) adequate inhibition to provide sufficient array space for the appropriate information, (2) the productive use of mentation which supplies the coded array with the spoken equivalent (phoneme) of the grapheme to be read, and (3) discrimination of the neural pattern on the uncoded array representing the grapheme and of the neural pattern on the coded portion of the array representing the phoneme. These processes are considered below.

Inhibition. Inhibition is the process which serves to select information for the informational array by blocking the transmission of unwanted input. Inhibition is utilized to form the channel containing task-relevant information while blocking access to the informational array of those data which are not relevant to the task at hand. The beginning reader need have appropriate strategies with which to deploy inhibition against unwanted input. For example, in reading one would want to inhibit auditory input, much of one's bodily cues, most of the visual information except that concerned with form discrimination, and most mentation except that concerned with producing the phonemic equivalent of the grapheme being viewed. Just a portion of this task, say that of ignoring movement and color within the visual field, may constitute a huge developmental achievement. Research by Maccoby and others (e.g., Maccoby & Hagan, 1965) has shown that this inhibition of task-irrelevant information within the visual sphere develops throughout elementary school and does not approach adult capability until well into junior high school.

In initial reading acquisition, a major portion of the array need be given over to the analyzer data carrying information about form, and thought data carrying information from storage about the phonetic characteristics of the associated graphemes. At this initial stage of reading words, all other information would be considered task-irrelevant and best inhibited. While such major inhibition is difficult for the young child, his problem is compounded in that the necessary channel to be formed is constituted of two different sets of input, one from the visual sense and the other from the child's own stored material, i.e., mentation. Whereas both of these sources are carrying linguistic information, thought by the Information-Integration theory to be maximally difficult by virtue of their complexity, the visual-mentation channel must be

operated efficiently if the child is to read adequately. The less efficient is the inhibition process at inhibiting task-irrelevant information, the more difficult the child will find this initial reading experience.

Productive mentation. Given appropriate receptor orienting acts, and the proper functioning of the analyzers relevant to form discrimination, and the efficient use of the inhibitory mechanism in selecting an appropriate set of grapheme data, the visual portion of the data will automatically come to the uncoded array. The phonemic information, however, needs to be generated by the child himself. This productive requirement adds to the difficulty in initial reading acquisition. These two basic processes necessary for initial reading acquisition, inhibition and mental production, are likely the most critical sub-skills distinguishing reading acquisition from language acquisition and accounting for the greater number of children who encounter problems in reading than in initial language learning. Because auditory cues are typically more intrusive than visual ones (Weiss, 1961), that is, because auditory cues have a generally higher probability of gaining access to the informational array, fewer demands are placed on the inhibition process when acquiring spoken language than in learning to read. Secondly, the productive problems of speech acquisition are somewhat simplified by the vocal response being public and hence susceptible to shaping by the adult environment. In reading, the internal production of the phonemic equivalent of the grapheme is preferably not vocalized, thereby making the task less susceptible to adult correction. Of course in practice, the child beginning to read is encouraged to say the words "out loud" so that correction can be applied. This process, however, is costly and tedious for adults as it cannot be undertaken in the course of normal every day activity as is the case in language acquisition.

Discrimination. For normal progress in initial reading acquisition to occur, the child must be able to discriminate the grapheme and the associated phonemes in the language. The child must be able to recognize as different and unique each letter or letter combination which gives rise to a unique sound in the language and recognize as unique each of the sounds. It is very important to understand that the child must be able both to recognize the uniqueness of each phonemic as well as each graphic element. While it has empirically turned out to be the case that problems in auditory discrimination hamper reading acquisition, an adequate theoretical explanation of this finding has not been available. The present theory requires that the child produce the appropriate phonemic elements which constitute a word so that the meaning which is evoked by this phonemic pattern can be integrated with the neural pattern generated by the grapheme. An ability to produce the neural equivalent of each of the speech sounds, whether or not this neural pattern is allowed to give rise to vocal behavior, is necessary for the integration process to occur. In this context, a truly expressive language disorder is one which entails difficulty with the motoric output of the neural representation solely and, hence, should not affect the reading process itself except inasmuch as teaching becomes impeded by a communication problem between the pupil and instructor.

There are two more issues that need mentioning here, one concerns the nature of the phonemes produced by the child and the second concerns the learning required in order to discriminate the neural patterns which represent the various graphic elements in the language, for example, "b" and "d".

The neural activity produced by the child which represents the unvoiced equivalent of the grapheme need not be single phonetic units but can be whole words or even phrases. It is entirely feasible that a child taught by the word method, for example, could produce the neural equivalent of the whole word on the coded array rather than produce separately each phoneme. In intermediate cases the syllable might be the unit produced. As reading acquisition progresses and familiarity with the grapheme patterns increases, the size of the unit produced would increase and come to represent the whole word or even small phrases. The principle being stressed here is that some unit of the neural equivalent of spoken language must be produced on the coded array and integrated with the equivalent unit of written language on the uncoded array, be the units graphemes-phonemes, syllables, words, or even phrases. Efficiency dictates that the unit chosen for production be as large as possible and come to approximate the unit from which the meaning of the words can best be understood. For the beginning reader, however, accuracy will be more important than efficiency; knowledge of the phonetic code whether by explicit teaching or through repeated experience in reading, provides the child with the productive capability of generating the neural equivalent of the spoken word from which meaning will be evoked such that the integration process can proceed. The value of phonics lies in this generative capability, allowing the child to "sound out" words, thus yielding the phoneme-meaning neural activity for integration with the grapheme pattern. Phonics, as an instructional program, aids the integration process by helping generate the phoneme-meaning neural activity. The word method, as an instructional procedure, differs from phonics in substituting rote memory for phonic production. Both methods can be seen as having the same goal, that of providing the child with the phoneme-meaning neural activity for use in the integration process with the grapheme pattern. The sometime success of both methods is consequently understandable; reading acquisition generally proceeds in the same manner under both systems, through integration. What differs is the method used to produce the phoneme-meaning neural activity, phonic analysis or rote memory. Each method has its strengths and weakenesses which will be more or less critical depending on the child's specific skills. A child with poor auditory discrimination, for example, would be expected to have great difficulty with a phonic method while the word method would be inappropriate for a memory-disabled child.

As words become more familiar through repeated practice, their presence on the uncoded portion of the array will begin to give rise to the neural equivalent of the word on the coded portion of the informational array which previously had to be produced from mentation by the child. Further on in time, many words will become familiar such that the graphic representation on the informational array will itself be sufficient to give rise to the meaning of the word and the various associations to it without either the need to produce the auditory equivalent or to have the auditory portion evoked by the visual portion. A unique pattern of neural activity which is reliably antecedent to some other pattern of neural activity will come to evoke that neural activity. Thus, the process of integration involves imbuing the visual information (neural uncoded grapheme representations) with the ability to evoke the same meaning and associated mental activity and vocal response as was previously evoked only by the spoken or imagined word. Through the process of integration, the necessity to produce the phonemic equivalent of the word and subsequently the necessity of having the visual equivalent evoke the phonemic equivalent on the coded array prior to its evoking the meaning and associated mental activity are obviated; the meaning then flows directly

from the graphic representation itself. This integration process is a continuous one throughout the reader's history such that even the adult reader will at times need to use the most basic productive methods to understand a new word and more typically will have to utilize the auditory translation of the visual grapheme onto the coded portion of the array in order to obtain maximum meaning from the written word. However, for the practiced adult, a large portion of his everyday vocabulary can likely be read by having the meaning directly evoked by the visual information alone.

Finally, comment must be made about the learning history necessary to discriminate the neural patterns on the visual portion of the uncoded informational array. What experience is necessary to allow one to discriminate the neural pattern provided by the analyzers when presented a "b" than when presented a "d"? As Kohler (1947) has shown in his classic demonstrations of reversed visual images, the exact orientation of a stimulus presented visually is quite arbitrary; the person can learn to adjust his reactions to a world even inverted by prisms if only this "distorted" information be consistent. To a subject newly wearing glasses with prisms which invert the visual field, something that appears to be above him will in actuality be below him. Though he will initially reach up for the object, he will quickly learn through repeated practice that an object so perceived is to be grasped by reaching down. The point I wish to draw from these classic demonstrations is that the meaning of any sensory input is determined by its lawful relationship with other known input. Without some correlation with some other neural pattern which is already known, the meaning of a new input cannot be learned. This contention is most clearly demonstrated in the area of perceptual learning. As Held (1965) has shown, the meaning of an object in space cannot be grasped either literally or figuratively by an arm which has been restrained during development. Experiments with monkeys who have had their limbs restrained take a period of time to learn to associate (integrate) the kinesthetic cues from their own movement with those generated by the visual analyzers. In a similar set of studies, Held has shown the importance of the kinesthetic system for perceptual learning in cats. In the context of the present model, the learning of patterns of visual material on the informational array would be seen as gaining meaning through correlated occurrence with the cues on the informational array provided by the kinesthetic feedback from the motor system.

Returning now to the specific problem involved in pattern discrimination, recognizing the difference between two graphemes involves the integration of kinesthetic and perhaps tactile information with that from the visual system. A "b" therefore is different from a "d" in that with reference to one's own body, a "b" is oriented in a different direction than "d". One must, therefore have developed throughout early childhood the ability to integrate kinesthetic experiences with visual ones in order to provide a sound basis for the more intricate visual discriminations necessary for reading. We will see in the next section that failure of this integration of visual and kinesthetic-tactile inputs is postulated to be responsible for the visual discrimination problem so often seen in learning disabled children.

Meaning Evoked by the Coded Array Representation

The integration process by which the visual grapheme comes to evoke the meaning of the auditory equivalent, requires that the beginning reader have

the capability not only of producing the neural equivalent of the spoken word but also that this equivalent once produced have the capability of evoking the meaning and associated ideation appropriate to that spoken word. The whole point of the productive aspect of the reading process is that in producing an internal equivalent of the word as it would be voiced begins a chain of mental activity which is the experience of the meaning of the word and the other associations that it evokes. If the generation of the internal equivalent on the coded portion of the array does not serve this function, then the visual pattern cannot come to evoke the meaning of the word either. Thus in addition to the requirement that meaning and associated ideation flow from the internally produced coded representation of the word, the meaning must also be capable of flowing from the visual equivalent, i.e., the integration process must be intact.

Feedback from Mentation

Reading is not so much a process of information transmission from the printed page to the vocal apparatus of the reader as it is a process of understanding, gaining meaning from the collection of words on the page. The meaning of the words in a sentence have to be understood in the context of the other words; similarly, the first sentence of a paragraph has to be taken into consideration to derive the full understanding of the final sentence. So too is it with paragraphs and chapters. Thus, reading involves the construction of an imaginal system.

Within the context of the Information-Integration Theory, this function of higher-order integration is thought to be accomplished by the feedback of mental activity either in the form of thought or non-verbal ideation (imagery) onto the coded portion of the informational array. Thus, some portion of the information processing capabilities need be given over to the thoughts derived from the content of one's reading. Though one may at times pause in one's reading specifically to ponder the content of what one has just read, more typically this process goes on concurrently. The reading of new material does not stop; rather, a portion of the coded information array is used to carry the neural activity which is experienced as thoughts about the reading, typically associations to what one has just read.

This feedback onto the informational array has two central purposes, the first and most important being one of comprehension. In the manner of the integration process, new information being read is combined with the previous information brought back onto the informational array and combined to yield a unique set of mental reactions which would not occur if the feedback were kept off of the informational array.

The second purpose of the feedback onto the informational array is that it helps form a cue base from which the words in the story are made more readily decipherable. This operates through a process of probablistic prognosis, by which the presence of a certain general set of ideas makes it more likely that some words will be present in the immediate future in the story than will some other set of words. Thus, having "in mind" the specific content with which one is dealing, the reading becomes easier by virtue of one being more able to guess what the ensuing words will be. Parenthetically, it could be noted that pictures in the text also serve both of the above purposes, aiding comprehension as well as providing additional cues about the context within which the story is occurring.

I have thus outlined the skills necessary for adequate initial reading and to some extent specified how this basic acquisition process changes with practice. In the following section, I shall discuss the problem of receptor orienting acts and then in the concluding section describe how disability in one or more of the processes necessary for adequate reading acquisition can lead to symptom patterns we see in specific learning disabilities.

RECEPTOR ORIENTING ACTS

It is obvious that learning will be impeded if the child does not orient to the information that is to be learned. Less obvious are the reasons for his failure to attend. It is not enough to claim that the child has a "short attention span", by which is usually meant that the child cannot (or will not) sit in one place and look at or listen to prescribed material for more than a brief period. This inattentive behavior can be caused by a number of diverse factors which the label short attention span can serve to obscure. It is necessary to analyze the short attention span in order to determine its properties, specifically the conditions under which it occurs and, equally important, the conditions under which the child's attention span approaches that of the normal child. This section considers attention solely in terms of overt behavior, receptor orienting acts which bring the child into contact with material to be learned.

There are two basic reasons why knowledge of the conditions under which inadequate receptor orienting acts occur or do not occur is critically important. First, to understand behavior, to know its meaning, one must know the functional relationships between the behavior and its antecedent (eliciting) and consequent (resulting) conditions. As we shall see below, all "short attention spans" though grossly similar are not alike when their antecedent and consequent conditions are considered.

The Behavior's Topography

Prior to considering the various conditions under which short attention spans are evidenced, we shall examine the character of the attending behavior itself as its variations may herald different underlying process deficits. Let us deal in turn with the duration of attention span, its course and variability, whether attention recovers after a reasonable rest period, and the associated affect. These characteristics of attending behavior share the same logical status as the general term attention span. They lack meaning apart from their functional relationships with other variables. For instance, it is all but meaningless to consider how long a child can attend without also considering what he is attending to. It is the characteristics of the inattention in conjunction with the associated conditions under which the behavior occurs that is important. Throughout this discussion, the reader must keep in mind that my point is that the inattentive behavior so frequently labeled "short attention span" is not a single type of behavior but is an overly general term which glosses over important aspects of the attending behavior and the conditions under which it is elicited. Thus, I use the term attention span because it is familiar to the reader while urging its more limited use in favor of a more careful description of the behaviors it subsumes. Also keep in mind that

throughout this section, attention refers to overt, receptor orienting behavior and not to the selection of information from the stimulus field.

Duration of attending. The notion of a short attention span literally denotes that the child is unable to divest his attention in a task for as long a continuous period as can the average child his age. The concept is routinely used without reference to the specific task the child is undertaking though it usually is assumed that the task involves educational materials in a classroom setting. Though this assumption is usually met, the specific situation is treated as unimportant relative to the child's trans-situational attentional skills. The short attention span is conceived of as a characteristic of the child that he brings to the school task as opposed to a response of the child to the school task. Though this distinction appears subtle, its implications are not. Failure to specify the conditions under which inattention occurs heavily restricts our understanding of the child's attentional difficulty as will be demonstrated below.

Duration of attention span, whether assessed with reference to specific materials or considered (erroneously I believe) as a characteristic of the child, has important theoretical and pedagogical implications. The pedagogical importance is obvious as any teacher, who has tried to teach a child who persists in looking out the window or more generally into space, will attest. The theoretical importance equally obviously varies with one's theory of attention, here more specifically with one's theory of attentional maintenance. Why does an organism look at anything? And why does he persist in doing so? The Information-Integration Theory views receptor orienting acts as an extension of the information processing system and, hence, under the control of the progenerative mechanism. Just as information which succeeds in generating further neural activity will increase its probability of subsequent selection for the informational array, so too will the probability of those receptor orienting acts which enable that specific information to be selected increase in likelihood. The reverse situation also holds and is more germane to educational disabilities: if information of a certain type fails to stimulate further neural activity, then its selection will become less probable and the attendant receptor orienting acts will decrease in probability in favor of other receptor orienting acts which do yield information which stimulates further neural activity. The child who gazes out the window or bothers his neighbor does so because these activities and the attendant orienting acts provide the child with more imaginal activity than does the material he is supposed to be working on.

The literature contains reference to two types of problems concerned with the duration of processing (attention). One type is represented by the so-called hyperkinetic child whose attention span is measured in seconds unless a barren stimulus environment is provided to eliminate distractions. The second is not so specifically codable and is represented by a large portion of the learning disabled population. Their reduced attention span is more typically measured in minutes. I believe the first case to comprise a sample of children more homogeneous with respect to the reasons for the short attention span than the latter group which may contain children with many more different underlying cognitive problems. A theoretical explanation of these examples of reduced attention span is clearly in order. Because I believe these cases of inadequate receptor orienting behavior are secondary, deriving from disorders in the child's ability to process information, the theoretical exposition more properly

belongs in the following section. Let us continue here with a consideration of the dimensions of short attention span behavior followed by an examination of the conditions under which this problem may occur.

Attentional variability. Short attention spans are surely not characterized by optimal functioning for a given period of time followed by minimal functioning. Such abrupt shifts are simply not generally characteristic of biological systems. Rather, a child approached afresh will look at stimulus material and/or appear to listen carefully more so than he will after fifteen minutes of instruction. The probability of the attending behavior will not be constant over time. Neither need its course from attention to inattention be regular. It is conceivable that some children are distractible in the sense that they have low reception thresholds for situational stimuli defined as task-irrelevant. Such a problem would generate an irregular pattern of attending covarying with the presence of distractor stimuli (though fatigue, i.e., satiation for the task-relevant stimulus materials, may add an element of progression to the inattention). Other learning disabled children, being no more distractible than their normal counterparts, would be expected to show a course of attention commensurate with the factor or factors which shorten their attention span.

In addition, the course of attention during the shortened span may be controlled by events only indirectly related to the cognitive disability. For instance, the child's interest in the task may remain minimal throughout his so-called span of attention though he cooperates with the teacher for limited periods of time. The length of his attention span and the progressive inattention in such a case would be a function of the teacher's reinforcing power for the child coupled with certain dispositional characteristics of the child, for example, whether he is cooperative, desirous of pleasing adults, threatened by failure, and so forth.

Recoverability and associated affect. Associated with the course of attending behavior are two extra-behavior considerations: recoverability and affect. What are the necessary conditions for resetting the attentional span, however brief the span itself is? This question, significant for our understanding the bases for short attention spans, has pedagogical consequences: Is the passage of time important in resetting the child's span of attention? What other events besides the passage of time cause the child to approach the task anew? Were one able to answer these questions and control those events, one could command the child's attention. The point here, as before, is that the variables related to attention spans must be systematically studied if the notion of attention span is to attain meaning. My guess is that recoverability of attending is not related to sensory or biological factors but rather that, like the length of attending itself, recoverability is learned behavior under the control of extrinsic, social rewards and punishment. If the passage of time is important in recapturing the child's attention, it is due to the dissipation of anxiety and frustration, i.e., an emotional rather than a cognitive recovery with the passage of time.

If this hypothesis is correct, the affect associated with the shortened attention span would be an important variable for understanding reduced attending. As many skilled teachers are aware, keeping the child's attention is intimately linked with maintaining his confidence while reducing threat of failure. Thus, while emotionality may not initially be responsible for reading failure, its probable role in motivating task-avoidant behavior must

be acknowledged. As an aside, I would want to add that theories of reading disability based on emotional mediators and those advocating cognitive process deficits are not mutually exclusive. We need considerable thought and research aimed at understanding the interface between emotion and cognition as opposed to the nearly complete separation which now exists.

Conditions Affecting Receptor Orienting Behavior

The conditions surrounding the production of reduced attending behavior yield information additional to that provided by the characteristics of the behavior itself. Systematic research is required which would first provide reliable indices of attention span and second, provide normative data describing the attending behavior of average children under a variety of school-relevant conditions. The global notion of "short attention span" loses all meaning when considered in light of the situational variables discussed below.

Input modality. Treated as though it were a characteristic of the child, attention span is sometimes thought to be modality specific, each sensory modality having its associated attention span. In educational fields, the visual and auditory attention spans are the ones considered. Though a refinement over the global attention span concept, visual and auditory attention spans retain the notion that the problem is a characteristic of the child and not also situationally determined. What one is really interested in is not whether a child will orient his receptors but that he will encode the information he receives. The attentional acts are prerequisites for receiving information and are likely controlled by the degree of success in this endeavor. Therefore, their functioning should be considered in relation to the information. Were one to find that the nature of the information is not relevant to the lowered attention span, that is if duration of attention is lower than average across a wide variety of stimulus conditions, then one would have some basis for using the global term "short attention span". But one must end up with this designation after demonstrating that the attending decrement is trans-situational, not begin with it after only limited observation within the restricted stimulus conditions of the school room. A wide variety of situational variables, in addition to the modality of the stimuli involved, need to be considered.

Situational variables. The situational variables that must be considered in order to understand receptor orienting acts include dimensions of the task at hand, the situational context, the presence of distractors, and the immediate rewards for attending, both extrinsic and intrinsic, together with the reward history for attending in the given situational context. As these are all complex dimensions in need of systematic analysis, I shall only comment by way of illustration on the relevance of each.

Though obviously important in maintaining attention, the nature of the task is implicitly ignored when a child's attention span is noted; in fact, his attention may wander only on school-related tasks, perhaps only on those school tasks in which he is deficient. One must ask, "does his attention wander during a baseball game?" or "while playing with trucks in the backyard?" I push this obvious point because I believe that for the bulk of the children said to have short attention spans, the problem is specific to quite circumscribed stimulus conditions, which makes the label "short attention span"

terribly misleading. Though it is also likely that a child's inattention generalizes to tasks he is capable of accomplishing and hence comes to resemble a more pervasive deficit, it behooves us to distinguish whether the child is unable to control his attention, whether he fails to derive the information sufficient to maintain attention (processing), or whether he has learned to avoid certain types of encounters because they prove to be punishing.

Let us consider the reward context next. There is no reason to believe receptor orienting acts are not influenced by rewards and punishments as are other responses. Orienting to and maintaining focus on material in a context where failure is likely is, indeed, a tall order. I hasten to add that I have presented no data to demonstrate that rewards and punishments are relevant variables determining receptor orienting behavior, but have only indicated my confidence in this assertion. The recent popularity of behavior modification, a framework within which this immediate discussion could fit, has led to an uncritical over-acceptance of claims based on the law of effect. It is not enough to assert that relief from the anxiety and frustration or failure motivate inattention. More basically, to claim that rewards and punishments are controlling a given behavior, one need demonstrate that manipulation of the reward-punishment contingencies causes commensurate changes in the target behavior. I believe that such an analysis would verify that for many learning disabled children, avoidance (inattention) is motivated by punishment and the relief from discomfort and that scheduled rewards, both primary and social, can significantly affect this picture. However, one must keep sight of the historical context: why has one child failed thereby causing us to utilize extrinsic rewards to recapture his attention while another child engrossed in his schoolwork has no need for our praise or tokens? The effectiveness of a reward in modifying behavior does not logically imply that the previous behavior was due to an absence of the reward anymore than the elimination of a headache by the administration of aspirin demonstrates that the headache was caused by an aspirin deficiency. One still must answer the question why the child failed in the first place: the correct answer may, indeed, be that he failed to be rewarded but this would have to be proven, not assumed from the evidence that reward is capable of altering the target behavior. I stress this point because I believe the administration of extrinsic rewards to encourage attending are prophylactic at best; if useful in teaching the child, they certainly should be administered but we should not let the recent popularity of behavior modification deceive us into thinking that the child's interest in learning derives from well-timed praise and M & M's. The danger is that one stops searching for the reasons why children fail in school if one can make some inroads into the problem by shaping their skills with well-timed rewards. If we are so deceived, we are left with a weak remedial technology and little knowledge of the underlying process deficits or their causes.

A final major dimension important in assessing attention span is the role played by distractor stimuli. Distractor stimuli, defined simply as information irrelevant to the central task, by their very nature impede performance if they are process instead of the task-relevant material. Their detrimental effect acts on the adequate as well as the retarded reader. They may, however, be differentially important in their effect on the receptor orienting acts of those learning disabled children with (organic) minimal cerebral dysfunction. Considerable evidence with brain-injured adults shows that performance on copying tasks is differentially impaired by visual distraction and this

fact has been used to aid in the diagnosis of brain damage (Adams, 1969). Whether or not all performance deterioration in excess of that experienced by the average child under conditions of high distraction are due to brain lesions is a very difficult question to answer. Nevertheless, marked deterioration of attentional skills under distraction conditions may herald a unique process deficit, whether organically mediated or not and, hence, deserves our attention. Given that classrooms tend to be loaded with visual and auditory distractors, those children whose attentional skills markedly recover in impoverished stimulus environments may share a common mediating deficit. I would expect that the children isolated by such a procedure would be those diagnosed hyperkinetic by psychoeducational-neurological batteries.

Summary. In this section, I have described some of the situational factors important in assessing the child's gross attentional (receptor orienting) behavior. Knowledge of how the attending is modified by the stimulus modality of the central task, by the situational context of the task and the nature of the task, by extrinsic reinforcement and the child's reinforcement history, and by distractors in the situation would add immeasurably to our understanding of the inattention. The global concept "short attention span", applied to so many learning disabled children, obscures so many critical distinctions that it covers more information than it conveys. It remains important to note each child's attentional limits and even more important to examine the conditions under which the attentional problem is exacerbated or ameliorated. This more detailed assessment of the receptor orienting behavior can provide important clues as to the nature of the child's learning disability as illustrated in the following section.

SPECIFIC LEARNING DISABILITIES

I have tried to show in the previous section how a behavior as complex as the orientation of the receptors to the educational material is likely under the control of a wide variety of different variables. As such, using this behavioral index as a measure of a single construct, "short attention span", thought to reflect a capacity of the child, would seem to be inappropriate. As previously discussed, receptor orienting behavior is under control of both extrinsic and intrinsic rewards; it is the spirit of the Information-Integration Theory that the intrinsic rewards are the stronger of the two in the educational situation. Extrinsic rewards such as candy, checks and tokens negotiable for material goods, and even praise as used by behavioral management technicians are only necessary when the child's disabled functioning prevents him from attaining the intrinsic satisfaction from learning.

The specific disabilities considered in this section are concerned with irregularities in function within the context of the Information-Integration Theory. Inadequate receptor orienting activity is nearly always characteristic of each specific learning disability but often for different reasons. The exact character of the inadequate receptor orienting behavior is sometimes predictable from the specific disability posited. Hence, receptor orienting behavior will be considered as derivative, secondary to other disorders of information processing and organization, and not as reflecting a primary disability itself. Four categories of specific learning disabilities are considered below: (1) disabilities deriving from the failure to receive

proper information on the array, (2) disabilities deriving from the failure to produce the proper information for the informational array, (3) disabilities deriving from the failure of the informational array to evoke neural activity in the imaginal system and (4) disabilities deriving from task-irrelevant content occupying the informational array.

Failure to Receive Proper Information on the Array

Reading acquisition will be adversely affected if the necessary information fails to be received on the informational array. A number of processing disorders could be characterized by the different reasons for the appropriate information failing to reach the array including (1) defective analyzers for form, (2) irregular signal life of visual information, (3) inadequate channel formation due to ineffective inhibition, and (4) visual information being low in the information-selection hierarchy. These disorders and the associated behavior deduced from the Information-Integration Theory are discussed in turn.

Defective analyzers for form. A most basic type of reading disability would result were the analyzers which carry information about form defective. Typically, learning disabilities are defined in the absence of sensory disorders (Clements, 1966) so that it is germane to question whether defective analyzers constitute a sensory or a central processing dysfunction. This issue is to some extent definitional; however, analyzers typically are not single receptor cells but instead are combinations of receptor and neural cells which act together to produce a specific type of information about the environment. Subtle and exact relationships are required between the elements within an analyzer in order for it to transmit its specific information, at least as far as our understanding of these systems allows us to speculate (Lindsey & Norman, 1972). Thus, analyzers are not truly sensory nor are they solely central in that the sensory receptors are an integral part of the analyzer mechanism. The more important basis for distinction would perhaps be that in not being strictly sensory, analyzer defects would not be readily corrected by known ophthalmic techniques.

Defective form analyzers would have a simple and direct effect on reading; the child would have an insufficient amount of data on the informational array concerning the form of the graphemes in order to make the necessary discriminations. Despite the simplicity of this hypothesis, it would be exceedingly difficult to assess whether a child was having difficulties of this basic kind. While problems in visual discrimination tasks might be caused by defective analyzers, the possibility remains that poor visual discrimination performance could occur even though the form analyzers were structurally intact. Such could occur for at least two reasons. First, the probability that form analyzer data entered the array could be extremely low due to inadequate extrinsic or intrinsic rewards for selecting this information. Second, the child could have failed to integrate form data with other information especially kinesthetic and hence, according to the basic tenet of the Information-Integration Theory, the form information would lack meaning by virtue of it having limited relationships with other information.

Because it is the case that poor visual form discrimination alone is not sufficient evidence for defective form analyzers, one questions what evidence would be necessary to conclude that the child had defective form analyzers.

There are two answers to this question, neither of which are entirely satisfactory. The first is that a single measure of defective form analyzers would need to be a direct neurological assessment of the analyzers' ability to output information when stimulated. While measurement of this type is theoretically possible and, in fact, accomplished through the chronic implant of electrodes in laboratory animals, such methods are not possible with humans. Thus, while a single direct measure of analyzer functioning is feasible, we await development of our present technology to devise a single, direct measure of analyzer firing.

The second answer to the question as to how one might assess the presence of defective analyzers transmitting form information to the array would be to examine the total pattern of disability to ascertain whether it has the following characteristics: first, the disability resulting would be a very pervasive one, extending beyond the classroom into all aspects of the child's life. After all, the human is constantly called upon to make discriminations based on form, living in an environment populated with various objects. Even though reading may place extreme demands on our ability to discriminate form, it somehow seems reasonable that basic structural problems in the form analyzing mechanisms would be disturbing enough to show themselves in the child's everyday behavior. For example, the poor visual form information would prohibit adequate visual-kinesthetic integration resulting in the child appearing clumsy and having little interest in most visual-motor sports such as baseball and little interest in visual-motor activities such as drawing and writing. The everyday processing of information in the environment about form would be difficult; aside from appearing clumsy, the child might also misjudge distances and bump into objects as though he had a visual acuity problem. Entertainment devices such as television and movies would have reduced interest for the child and in extreme cases would be experienced as confusing and upsetting.

A second major characteristic of children with defective form analyzers would be their slow but regular acquisition of information about form. Once the form characteristics had been learned, the child could be expected to retain that knowledge for recognition at a later time. This pattern can be distinguished from problems where apparent gains are continually lost and have to be re-established, a pattern likely caused by faulty selection of intact analyzer data whereby learning at one point in time with the appropriate information on the array may not be evidenced at some later point due to the child's failure to reduce the proportion of task-irrelevant information on the array. Hence, when the selection of appropriate information is the problem, the behavior will look much more erratic where in the case of defective analyzers, once a correct response has been learned to the analyzer data even though these data are fragmentary, it should be maintained. Any alteration in the format of the material to be learned which would accentuate form characteristics giving the defective system as much opportunity as possible to transmit information about form, should aid the child in performing at a more satisfactory level.

With the assessment of defective form analyzers so difficult, it is nearly impossible to estimate what the incidence of such a problem might be. My guess would be that it is very low. Certainly, perceptual motor tests like the Bender Gestalt Test and the Benton Visual Retention Test would find such a child performing extremely poorly. Thus, the population of children afflicted with defective form analyzers would need be a subset of those learning

disabled children found to be deficient on visual motor tasks. Further, as noted above, the disability should be sufficiently great to be noticed in other aspects of the child's life. Typically, children are not found to have difficulty on visual motor tasks until after they have done poorly at school, no one suspecting they were having difficulty in form discrimination until the more exacting demands of school were upon them. Though only an intuitive guess, I surmise that problems with defective analyzers would more likely be noticed prior to the child's failing at school. This small group that is left may constitute what we now see as the child with a very severe perceptual-motor handicap.

Irregular signal life of visual information. Neural activity transduced at the receptors from physical energy has a characteristic signal life. Within the visual system, it has been shown that neural activity carrying information about form is available for as long as a second after termination of the external stimulus (Sperling, 1960). The persistence of the neural activity after the offset of the initiating stimulus is typically referred to as iconic memory within the visual sphere (Neisser, 1966).

The persistence of the neural activity after the offset of the eliciting cue would reasonably serve the function of providing the organism with visual information while the eye moves to register new input. It is generally thought that little or no information is gathered by the eye during saccadic movements but that a series of more discrete "snapshots" provides the visual information for the organism. Consequently, one could consider the difficulties encountered were the signal life of the output from the analyzers responsible for form either too brief to span the time period between saccadic movements or conversely too persistent to surrender its space on the informational array to information gathered by the subsequent eye fixation.

In the case where the signal life were too brief, the problem for the child would be that he would have insufficient time to integrate the visual form pattern with the phonemic equivalent on the coded array. By the time he were able to produce the corresponding phonemic representation for the graphemes on the array, the grapheme representation would have faded making integration with the phoneme on the coded portion of the array less efficient. Consequently, reading acquisition would proceed very slowly, the child having to cover the same graphic elements repeatedly until the integration leading to understanding of the graphemes could be accomplished.

The learning process should be progressive, the child's performance accurate though tediously slow. Complicating the slow acquisition process, however, would be motivational factors as the child would actually be engaging in a task significantly more difficult than that for a child not so afflicted. Further, because visual information historically would not have been readily utilized by the child, it would have already been relegated to a low position on his information-selection hierarchy. By the time the child begins reading in school, he may already have learned to favor input from auditory, kinesthetic, or mentation sources rather than that from the visual system. Low preference for visual information has a progressive deleterious effect resulting from reduced practice at forming the visual-mentation channel necessary for reading. The lack of practice would be particularly detrimental in that the brief signal life of the form information on the uncoded portion of the array would constantly make the array susceptible to being overtaken by task-irrelevant

information. As the visual information fades, the array inherently becomes more sensitive to new input. Unless the child is able to maintain both his gaze on the material to be read and the inhibition necessary to preserve the visual-mentation channel, he will be particularly susceptible to distraction. As noted, the distraction probability is increased by the visual material to be learned being low in the child's information selection hierarchy and auditory material or extraneous mentation, which within the reading context is task-irrelevant, being high in the hierarchy.

The signal life of the visual form information may conversely be too long, resulting in it being confused with that from subsequent eye fixations. The problem that would be created would be similar to that sometimes experienced by children with eidetic imagery capabilities. These children can preserve a visual image for many seconds (Haber, 1964) and frequently need to blink or shake their heads in order to disrupt the persisting image. Within the context of the Information-Integration Theory, eidetic imagery is a productive capability of nonverbal imagery on the coded portion of the informational array rather than a persistence of the visual analyzer data on the uncoded portion of the array. Though the neural activity would be viewed as occupying different portions of the informational array, the problems encountered might be similar though less intense in this latter case. Specifically, persisting information from a previous eye fixation could have sufficient signal strength to confuse the pattern of neural activity on the informational array evoked by the following fixation by blending with it. It is highly speculative that extended signal life can be a problem. It is entirely possible that even the longest signal life would not create problems for new input entering the array which would have by virtue of its recency much greater strength. This question is an empirical one deserving of study.

The contention that length of signal life for visual form information is positively related to academic skills could most readily be investigated on an adult population. Sperling (1960) has described the procedure by which the persistence of the visual information can be assessed following the offset of the physical stimulus. The simple procedure involves a tachistoscopic presentation of a matrix of letters larger than the subject is capable of recalling totally. He is signaled after the stimulus has terminated whether he is to recall the top, middle or bottom row of letters. The number of letters correctly recalled in this partial report procedure is used to estimate the amount of the material available to the subject at the time he was signaled. This simple procedure is suitable for the examination of young children, thus enabling a rather simple and direct test of the issue of whether the disabled reader has an irregularly short or long signal life for visual form information.

Inadequate channel formation due to ineffective inhibition. It is critically important for reading that the child be able to inhibit a large portion of his potential stimulus environment and select for his informational array a combination of carefully modulated visual information and its phonemic equivalent produced through mentation. The mechanism responsible for the channel formation is the inhibition process which is thought to (1) utilize energy from the arousal system, and (2) develop efficiency through repeated practice at inhibiting various combinations of events. The primary cause for malfunction in the inhibition process would be an irregularity in the level of arousal afforded the process. Either insufficient or excessive amounts

of arousal would prove detrimental to the inhibition process. Only one of these conditions, that of insufficient arousal, would theoretically produce the kind of behavior that would fall within the domain of learning disabilities. The other condition where arousal is excessive would result in a symptom pattern resembling infantile autism, according to the Information-Integration Theory. Excessive arousal would create a condition of extreme inhibition which the immature organism would not yet be capable of deploying appropriately. Consequently, inhibition would be directed summarily at large segments of input resulting in the organism establishing and maintaining very narrow channels. Due to the great amount of inhibition, distractability would be very low. Integration, requiring the simultaneous processing of two or more inputs, would be minimal, and the resulting experiences, in being drawn from a single or restricted set of input sources, would have little acquired meaning. I include this very brief sketch only for completeness and now continue to the case where inhibition is insufficient due to inadequate levels of arousal.

Lowered arousal results in a failure of inhibition to hold unwanted material off of the informational array. The extreme case, though hypothetical, illustrates the problem inadequate inhibition creates. With no inhibition at all, entrance of information onto the array would be governed by the type and intensity of stimulation in the environment, the organism's selection hierarchy, and satiation. The organism essentially would be at the mercy of stimulus variation, any signal that differed significantly from those on the array being able to constitute a new channel according to the signal detection model described previously. Without inhibition, the level of informational analysis would be restricted to that dimension which caused the source to be processed in the first place. Lacking complexity, the information would quickly satiate making the array once again maximally susceptible to new input. In short, the organism would become "stimulus bound", drawn about by changes in his environment.

While inhibition would never be totally absent, a less than normal amount of arousal could still be highly detrimental to educational tasks requiring precise information selection. The clinical picture observed would be one of a child who in present-day lingo is incapable of "getting into anything", of being equially interested in everything but not really interested in anything. One would see a child who is always on the move, stimulated by each strong stimulus in the environment but who in a stimulus-free (or reduced) situation would emit very little activity. The child would be initially attracted to an object only to put it down within seconds. Though initially interested, that interest would appear superficial and easily satisfied. These characteristics are typically among those attributed to children called "hyperkinetic" or "hyperactive."

The lack of sufficient inhibition and practice at its deployment allow for constant intrusion of external stimulation onto the informational array. With the informational array controlled more by strong external stimuli and strong bodily states than by mentation on the coded portion of the array, the child's motoric and mental behavior will be totally affected. First, his behavior will lack direction. Direction comes from the continuity of cues present on the coded portion of the stimulus array; recall that one's own thoughts and symbolic conceptualizations of immediate goals form a portion of one's cue base. It is the presence of this cue base to which we give over some of our array capacity that allows us to return to our work after being

interrupted. The child with inadequate inhibition, being continually disrupted from any "train of thought" (coded array data), will appear to act in non-purposive ways. Purposiveness may not even be evidenced when the child is placed in a more restricted, stimulus free environment because input from mentation will be low in the child's information-selection hierarchy.

The second major effect of insufficient inhibiton derived from the first; the lack of direction caused by the child's behavior being dictated by strong stimuli will result in the storage of atypical experiences. Much of his experience will be of single modality events, strong noises, bright colors, unintegrated with events from other input sources. Experience will be terribly disjointed such that the child's train of associations will be affected; thought will be limited in amount and associations to spoken or written verbal material will be primitive, atypical, and few.

Not being heavily directed by information on the coded portion of his array, the child further will be unable to maintain a set. Recall that sets to respond in a certain way are predicted on coded array usage. The person readies himself for a coming event by drawing from thought a representation of what is to be expected and entering it as a neural pattern on the coded portion of his informational array. The child without sufficient arousal loses in preparatory tasks both the value of increased inhibition and that of coded array facilitation of raw data interpretation.

Limited use of the coded array abdicates the longer signal life advantage coded material has over uncoded. In addition, the coded array rehearsal mechanism is not utilized fully. Consequently, those tasks which require active rehearsal so that traces reaching the coded portion of the array are maintained will be performed very poorly by children with insufficient arousal.

Tasks which require not only rehearsal but even simple decisions will take longer by virtue of the coded array being interfered with by new input from the senses or other bodily sources. More specifically, the pattern of behavior would appear more variable than the normal child's with some decisions being performed very rapidly and correctly with others being performed slowly, having been interrupted by the neural representation of some irrelevant event entering the array.

The neural activity which flows from the array (motor and mental activity) will be relatively undifferentiated because the level of information commanding array space is so superficial. Only through integration, by allowing neural activity from two or more sources simultaneously onto the informational array, can motor or mental activity become more refined. Initially, one's reaction to external events is gross, the infant startle reaction perhaps being prototypic of the strong motor reaction to supra-criterion external sensory stimulation. Because the organism makes discrete motoric activity, kinesthetic feedback is assured and the possibility that the neural representation of external stimuli will become integrated with the information about one's own position in space is this assured. In time, the motor response and its attendant kinesthetic feedback become more integrated with the specific external cue. For example, a child unfamiliar with playing catch with a ball would react differently if surprised by a ball being thrown toward him than would an experienced child. Where the first might exhibit a response more closely associated with a startle reaction, the second's motor response would be more refined and adaptive likely involving reaching toward the ball.

This example of motor behavior illustrates the general process by which the neural activity which flows from the informational array is continually shaped by the integration process. With repeated trials, the repetitive aspects of the neural pattern on the array come to evoke the post-array neural activity. For the child with a history of limited coded array usage, mentation flowing from the informational array will similarly be unrefined and somewhat typical because the informational array's coded portion has not sufficiently often entertained the neural activity representing thoughts and nonverbal ideation and, hence, integration within the ideational system will be underdeveloped. Consequently, these children will have fewer and more atypical associations on word association tests which may constitute a very simple procedure evaluating many of the foregoing assertions about this type of child's thought processes.

Visual information low in selection hierarchy. A common problem caused by a variety of difficulties results when the visual information necessary for reading is low in the child's information selection hierarchy. It is not sufficient to admonish the child to "pay attention to" the relevant material; it is very possible that he may not be capable or at least not be practiced at such an information extraction task. We have already touched on two reasons why the visual form information would not be a highly probable set of data for the array to select. The first was that the analyzers responsible for form information might be defective. The second was that the signal life of the output from the form analyzers might be irregular. A variety of other conditions could also result in the visual information being of low priority for the child, and hence, cause him difficulty in reading. Without attempting an exhaustive listing of those conditions, I would like in this brief section the describe what the nature of this problem is for the beginning reader.

Visual form information being low in the subject's selection hierarchy is a statement not only of information reception priorities but also of distraction likelihood. Distraction is really no different from selection of information, distraction simply being the selection of information which is defined as task-irrelevant. Consequently, a child who has a high probability of selecting auditory information for processing will appear highly distractable in a reading task where processing visual information is required. In reading, one need extract in an extremely discriminative fashion, information about form; consequently, a large portion of the informational array need be cleared sufficiently to represent this information. Inhibition need be directed at the potentially disruptive input such that the difference between the strength of the data on the array and that of potentially disruptive input (d') will be reduced. Further, the criteria specifying the magnitude of d' required to constitute a new channel around distractor sources need be raised such that even when a distractor does break through the inhibition the child will suffer only a brief interruption of the reading task and will not process the distracting information further.

While the information selection hierarchy is flexible, responding to the demands of different tasks, it is not infinitely so. The degree of flexibility is determined in large part by the system's structural capabilities, especially the integrity of the form analyzers in the case of reading, and by the organism's history of information processing, especially with respect to practice in establishing channels and the accompanying deployment of inhibition. A child who for one reason or another has come to prefer information arriving auditorily or through some other mode than visual will become increasingly

less practiced at processing visual information, particularly whereas the information he would prefer is usually present but task-irrelevant. "Paying attention to" (continued processing of) visual information is a learned skill, the failure at which signifies not the child's stubborn intractibility but the working of his peculiar capabilities.

According to the progenerative hypothesis, information which does not stimulate further neural activity becomes less likely to be selected in the future. Thus, if for whatever reason visual information becomes less selected by the child, his inability to process visual information efficiently will be progressive. While in less severe cases the capability of processing visual information may still be acceptable, its failure to be used as often or in a preferential manner continues to encourage distractibility from the more preferred channels, likely to lie within the auditory or kinesthetic modalities or in mentation. In more extreme cases of decreased preference for visual form information, the ability to make form discriminations will be hampered as well. The meaning of any neural pattern on the informational array aroused by form characteristics in the environment is determined by the character of post-array neural activity evoked. Thus, for a symbol to have meaning, it must be recognized (discriminated) as a unique pattern and integrated with the neural representation of other events which already have meaning. In the case of reading it is likely that the auditory and kinesthetic systems are the most critical in providing the meaning with which the graphic symbols will become integrated.

Of these two sources of integration for the visual forms (graphic symbols), kinesthetic is the more basic developmentally and must be well integrated before the child enters school. Even the most basic knowledge about the visual environment such as the notions of "left and "right" must be determined with reference to the child's own body. Hence, the visual information needs to be integrated with the kinesthetic information if the child is to interpret his visual world correctly. In a similar fashion, the meaning of the pattern of neural activity on the informational array associated with various lines, curves and directionality needs to be integrated with the kinesthetic and other cues which inform the child about his own bodily position, if a unique and consistent response is ever to flow from each unique grapheme.

Perceptual learning is integrationally based and derived from experience with the visual environment. Studies using infra-human subjects have shown that the mere experience of having visual forms present in one's rearing cage will increase discrimination performance using these items as discriminanda (Gibson & Walk, 1956). Further, research in the Witkin tradition (e.g., 1965), has shown that the cognitive style of field dependence is related to poorer pattern recognition (Kaswan, Haralson, & Cline, 1965). Consequently, a person characterized by extreme field dependence, seldom using his own bodily cues to understand his orientation in space, would be expected to have difficulty integrating the visual information with the kinesthetic information provided by his own body. Hence, such a person would have greater difficulty in form discrimination (pattern recognition) and, hence, greater difficulty in reading. Data supporting this line of reasoning show that many learning disabled children are heavily field dependent (cf., Keogh, in press; Keogh & Dolan, 1972). From these data, the deduction is possible that field dependent persons in general will be poorer than their field independent counterparts at kinesthetic and tactile discrimination and in visual-kinesthetic and visual-tactile integration tasks.

I have not yet mentioned any additional reasons why visual form information would be low in the child's selection hierarchy. In an ensuing section I describe why, according to the progenerative hypothesis, the child less capable of having visual information on the array stimulate post array neural activity in the imaginal system will decrease his preference for that visual information. This explanation for visual form data being low in the selection hierarchy like the defective analyzer and irregular signal life explanations posits specific defects in the child's information processing system. It is also possible that an initially intact organism could come to have visual information low in his selection hierarchy through the sole workings of experiential variables.

For meaning to be attached to the neural pattern of information representing objects in the environment, these patterns need be integrated with other information which already has meaning. Visual information could fail to acquire sufficient meaning for the infant if he is unable to integrate it with data from other sources. Sight of the human caretaker may provide critically important initial visual data which can acquire meaning through their association with other information the infant experiences. For example, the visual information of the human face is consistently correlated with the cues of hunger and their satisfaction and with the tactile and kinesthetic cues resulting from being picked up and carried. Thus, as the research growing out of Spitz's work (e.g., Spitz & Wolf, 1946) has shown, the human face may serve a catalytic function for the visual sphere similar to that which the reflex system provides for the kinesthetic sphere. Both yield strong and consistent cues which provide an initial basis for integration, thereby catalyzing the integrational process of perceptual development.

The deleterious effects on institutionalized children denied the extensive interaction with the caretaking adult is well known (Ribble, 1944). This condition may represent the extreme of a problem experienced by reading disabled children whereby through some unfortunate circumstances their early visual experience may not have been appropriate to establish sufficient meaning (post array neural activity) for visually input information. Consequently, other cues may have become more informative and early in the child's life led to a relative disuse of the visual system. Any support for such a contention would certainly argue strongly for early childhood education.

In addition to the characteristics already described in this section, the child having visual form information low in his selection hierarchy would experience problems not only in reading or in manipulating graphic symbols but should also manifest problems in non-symbolic form analysis. Thus, he should resemble the child thought to have defective analyzers, the problem being a pervasive one not limited solely to schoolwork. The pervasiveness of the disorder is important because the Information-Integration Theory also predicts that inadequate stimulation of the imaginal system by visual graphic input will also interfere with reading but that in this later case, discussed more fully below, only preference for symbolic material should be low in the information selection hierarchy.

Failure to Produce Information

According to the Information-Integration Theory, production of the phonetic equivalent of graphic signals is necessary for the acquisition of initial

reading. The child must be active and capable of drawing upon his thought processes to produce the neural pattern representing the phonemic equivalent of the grapheme.

Production as a general problem. Just as visual form information can represent an inadequately low input in the information selection hierarchy, so too can the selection of one's own thoughts be insufficiently dominant in the selection hierarchy. With many possible inputs to the informational array, all vie for the same informational capacity. Where one child may be relatively ignoring of visual information, another may be equally ignoring of information potentially supplyable from his own long term storage. Such a child will have difficulty in reading because reading requires an active production of the speech sound equivalent on the coded portion of the informational array. The integration process through which the neural pattern representing the visual grapheme acquires meaning is limited by the child's capability of producing the neural representation of the phoneme which already has meaning accruing to it.

A child with a general productive problem should be readily recognized. He will appear quiet, exhibiting little productive speech. He will be poor at relating his own past experience and be deficient at activites involving "show and tell" type procedures. Though the child may be a persistent worker, he will need to have carefully planned materials to guide his progress as he will not sufficiently utilize thought entered onto the coded portion of his informational array as an internal guide. His relative disuse of the imaginal system will make him appear rather uninteresting and ungifted. He will probably do more poorly on individually administered intelligence tests which typically involve considerable verbal-expressive skills but will do exceedingly better on non-verbal intelligence tests such as the Peabody Picture Vocabulary Test.

Disuse of the coded portion of the array normally supplied quite heavily by the imaginal system will result in the child being deficient on tasks which require rehearsal. Rehearsal is a function of the coded informational array whereby the productive use of thought is capable of regenerating an item on the coded portion of the array, thus extending its useful life. Failure to use this reproductive capability can prove detrimental on a wide variety of school tasks.

One additional characteristic which results from a failure to use the coded portion of the array as one's cue base as opposed to reacting to the raw uncoded input is a relative liability to engage in inactive behavior. At the extreme, the child will have difficulty making the appropriate movements to signify hammering a nail, buttering bread, and so forth because these motoric behaviors for him are evoked by the neural representations of the objects themselves and the tactile-kinesthetic cues on the uncoded array and not by neural activity on the coded array standing for the object, i.e., the object's name. The extreme of this condition is expressive aphasia which suggests that aphasia is also to be explained in terms of the relative disuse of language as an internal cue base for behavior. Further, Sigel (cf., Rowland & McGuire, 1971, Ch. 7) has noted that many Black children have particular difficulty with categorization when pictorial stimuli rather than actual objects are used. Once thought to be a conceptual problem the children were experiencing, Sigel has reinterpreted these data stressing that the "representational mode" is an important dimension underlying intelligent behavior. Having the actual objects present provides the child the cue base which he typically uses for generating

further motor and imaginal behavior whereas the pictures represent an abstracted, diminished set of cues only sufficient if one first codes the object and uses this coded representation as the cue base for the further mental and motoric activity. The extensive training middle class children receive from their parents may be important in establishing the coded portion of the informational array as the more relevant cue base for the child and, hence, establish the thought system as high in his information selection hierarchy.

Relative disuse of the thought channel will have cumulative effects. Elaboration of the meaning of words and events is greatly enhanced by the integration of one word with another through their near simultaneous airing on the coded portion of the informational array and by the integration of words and thoughts with new sensory events through their simultaneous occurrence on the coded and uncoded portions of the array respectively. Paucity of imaginal activity on the coded portion of the array restricts the number of opportunitites the child has to form more complex thoughts and hence his associations to words will be simple, typical and sparse. The association pattern is somewhat different than that of the child whose information processing is hampered by insufficient arousal. This latter child's associations are atypical, reflecting his irregular stimulus-bound processing.

In brief, we have a picture here of a child who has limited verbal capabilities though he may appear attentive and responsive to his environment. He needs assistance in directing his activities and will do poorly whenever tasks requiring rehearsal or expressive or enactive behavior are called for. He will not be a particularly interesting child, his mental activity being very simple and typical, though he may be pleasant and interpersonally attentive and dependent.

Specific input irregularities and inadequate integration. Two more circumscribed disabilities involve malfunctioning of the productive use of thought: one is simply a more refined subset of the disorder immediately above, that being the specific inability to form as an informational channel the visual and mentation sources required for reading. This special case recognizes the possibility that the formation of the visual-mentation channel itself may be deficient despite the intactness of visual processing and of the productive use of thought.

The major sharing of one's information-processing resources between two or more sources simultaneously represents a developmental achievement. Whereas the integration of two inputs on the uncoded portion of the informational array may be the most basic integrational activity, exemplified by one's knowing an object via either sight or sound, forming a channel between coded and uncoded inputs for integration may be significantly more difficult. There is even the possibility that the former task, integration of two sensory inputs, may be aided by analyzers specifically designed to register multimodal stimuli, that is by cells which fire when either an auditory or a visual cue is registered. Consequently, though productive speech and visual processing may be intact, the necessary joint channel between the two could be inadequate. Flexibility in utilizing one's array can be as important as array size (capacity).

This kind of cognitive disorder postulated must be recognized as entirely speculative in nature. There is to my knowledge no research on this type of integration problem where thought and sensory input need be joined to arrive

at a satisfactory understanding. Typically, integration problems that have been studied involve two sensory signals and even this research is in its infancy. However, the deduction from the Information-Integration theory that such an integrational task is involved in reading acquisition would lead us to examine such integrational tasks in detail. It would be a relatively simple matter to construct testing procedures to assess the ability to deal simultaneously with information produced by the subject and that provided by the visual channel.

A second circumscribed difficulty some learning disabled children may encounter involves the specific inability to produce the phonemic equivalent of the grapheme being viewed. Rather than a generalized productive disorder, this problem involves the specific inability to form the necessary neural patterns on the coded portion of the informational array which if voiced would represent the phonemes corresponding to the graphemes veing viewed. Such a disorder is probably quite common because it is based in an inability to form the necessary auditory discrimination between phonemes. While it is possible for one to discriminate speech sounds without being able to reproduce them on the coded portion of the informational array, i.e., an articulatory disorder, it is more likely that the inability to reproduce speech sounds accurately derives from the inability to discriminate those sounds in the first place.

Though I know of no specific epidemiological evidence, it is my experience that auditory discrimination problems are quite frequent among learning disabled children. It has not ever been well understood why difficulty within the auditory sphere should interfere with reading acquisition. Such is obvious though within the present theory for the child must produce the phonemic equivalent on the coded array to integrate with the grapheme on the uncoded array for successful reading acquisition to occur. An inability to discriminate the relevant speech sounds and a resulting inability to reproduce them either vocally or "silently" on the coded portion of the informational array would necessarily hamper the integration process by not providing the necessary phonemic equivalent and the meaning which flows from it.

There is a general symmetry between the visual discrimination problems and those in the auditory sphere, failure in early integrational development being implicated. However, there are two main characteristics which make auditory discrimination problems different from visual ones: the first is that in reading acquisition the meaning derives from the auditory cue and must be integrated with the visual one. Hence, failure in auditory discrimination produces a more pervasive educational problem where failure in visual discrimination may be more limited to reading and related tasks. Second, auditory discrimination problems may derive not solely from inadequate processing of the auditory analyzer data but also from the interference of previous learning. Possessing a proper set of speech sound discriminations may not be sufficient and may even be interfering if a different dialect is utilized in the classroom. Even, though a child may be capable of discriminating and producing the speech sounds within his own dialect, accomplishing this task for a slightly different dialect, often that of the predominant middle class culture, may give him particular problems.

Because of the subtle differences that exist between the phonemes he is taught to associate with the graphic symbols and those he has learned in

the past which give rise to his ideational activity, he may be unable to accomplish the reading task efficiently. The phoneme as pronounced in one's own dialect versus the pronunciation of the teacher may be just different enough such that the meaning which flows naturally from the child's own internal production of the phoneme as he knows it is not so evoked by the phoneme he is being taught in school to associate with the grapheme he reads. Thus, he is trying to integrate two new sources of information, the grapheme visually presented and a phoneme he is encouraged to produce, neither of which have sufficient meaning for him. Hence, the reading process proceeds very slowly, progress being made only to the degree that the phoneme system of the child and that being used in the classroom overlap or to the degree that the phoneme system of the classroom can come to acquire meaning for the child.

Informational Array's Failure to Evoke Imaginal Activity

If information from a particular source is to be processed continually, it must stimulate post-information array neural activity. This activity may either be motoric or imaginal or both but some activity must flow from the information on the array for the probability that that source of information will be selected in the future to hold constant or increase (the progenerative hypothesis).

There are four distinct processing difficulties which can occur: (1) Does semantic input whether auditory or visual sufficiently stimulate imaginal activity (thought and imagery)? (2) Does visual form data efficiently evoke its coded array equivalent? (3) Does visual form information, though capable of evoking the coded equivalent, sufficiently come to evoke directly the imaginal activity? (4) Does the auditory input require substantial recoding in order for imaginal activity to be elicited? It is the failure to stimulate the imaginal activity, which through the progenerative mechanism makes reading more difficult by lowering the likelihood that the appropriate information will be selected for analysis in the future, that is basic to each problem.

Uncoded information to imaginal system defect. A pervasive problem would result if language symbols whether presented visually or auditorily did not readily evoke the neural activity representing the meaning and associations of words. Though the thought system itself may appear intact, i.e., the coded array, imaginal activity that flows from it, and feedback from the imaginal system, the linkage between the uncoded input and imaginal system might be defective. The result would be a generalized receptive language problem.

This type of difficulty, though uncommon in the extreme, might characterize to a lesser degree many learning disabled children. The problem is one in which language symbols do not evoke sufficiently the richness of meaning and associations of which the child is capable. Whereas only the symbolic, especially linguistic, functions are involved here, the child would appear otherwise intact; he would be well-coordinated, motorically and emotionally expressive, and at least of average capability. However, his difficulty in receptive language would limit his approach toward language and experiences with it and hence he would appear concrete and narrow in his thinking. Such a child would do well in early school activities requiring manual and social skills but would have increasing difficulty as more and more demands were placed upon symbolic capabilities.

Visual uncoded array to coded array deficit. A second problem in reading acquisition would result were the productive part of the integration process not to give way to the more automatic flow of the auditory equivalent (coded array) from the visual input. Initially, the integration process requires production by the child of the phonemic equivalent as the grapheme is viewed. Eventually, the coded portion produced by the child comes to flow from the grapheme being viewed. Thus, the phonemic equivalent on the coded array comes to act more like a response to the grapheme than a production by the child.

This integration procedure resembles classical conditioning which in turn may represent a special case of the integration process. At the stage of information processing in question, the visually received information on the uncoded portion of the informational array serves as a conditioned stimulus while the phonemic equivalent of the word produced initially by the child acts like an unconditioned stimulus. The meaning of the word and the associations to it act analogously to the unconditioned response. The integration process should result in the visual grapheme evoking the meaning and associations initially evoked only by the phoneme. Unlike classical conditioning theory, it is assumed that in the early stages of this process, the coded array equivalent (phoneme) comes to be evoked by the visual grapheme, thus mediating the meaning and associations. With repeated practice, this intervening step is eliminated. The deficit posited here is a failure in the early stages of integration whereby the coded array representation does not come "naturally" to follow from the grapheme but must continually be produced by the child.

Uncoded visual array to imaginal system defect. One eventually wishes to have the visual material evoke meaning directly without requiring the mediation of the phonemic equivalent on the coded array. Such efficiency likely characterizes only the reading of highly practiced words. Likely, adult reading is a combination of meaning flowing directly from the visual symbols and that requiring the mediation of the phonemic code, either flowing directly from the grapheme or produced by the reader in the case of unfamiliar or unpracticed words.

Failure of the reader to be able to drop out the coded array "response" and have meaning flow directly from the visual material, thus making reading more efficient, would constitute a specialized type of learning disability. Though initial reading acquisition might proceed satisfactorily for such a child, his later reading would be hampered by his being required to go through the slower and more tedious productive process even on highly familiar words. This immature type of reading is very time consuming and effortful and produces less imaginal activity relative to the amount of information processing necessary. Therefore, according to the progenerative hypothesis, the probability that the necessary information for reading would be sought would decrease. Failure to have meaning flow directly from the visual graphemes makes reading a more difficult task, requiring more array space to generate the same amount of imaginal activity. The progenerative hypothesis implicitly assumes that the reinforcing effects of imaginal activity are proportional to the processing effort (array space) required to stimulate the neural activity. Even though an immature reader is capable of deriving meaning from words, he will be less likely to choose reading as an activity if the meaning derived is very expensive in terms of processing effort.

Dialect problems. Typically, the pattern of neural activity representing phonemes on the coded array contains that information which is the child's idiosyncratic understanding of the relevant dimensions of his spoken language. This representation is likely mirrored by the child's speech, barring expressive problems. The child can most easily understand someone with a dialect similar to his own as the raw input on the uncoded array will be highly similar to that which he can produce himself and that from which his ideational and motoric activity flows. The portion of the neural pattern aroused by the unique aspects of another's speech, e.g., voice tone, do not obscure the shared aspects which the developing organism learns to process selectively.

Special problems occur when the internal code which gives rise to meaning does not correspond sufficiently with the speech sounds with which the child must deal. While we recognize intuitively this to be a problem when different languages are involved, we tend to ignore the importance of the problems created when the child must understand one speaking in a dialect somewhat different from his own. Within the context of the Information-Integration Theory, the neural activity which would represent the child's equivalent of a phoneme would be seen as significantly different from the neural activity aroused by the teacher speaking that phoneme. Hence, an integration task must be undertaken whereby the teacher's utterance on the uncoded portion of the informational array needs be integrated with the child's internally produced phoneme so that meaning can flow from the teacher's utterance. Essentially, the same formal requirement necessary to derive meaning from graphic symbols (reading) apply to understanding the teacher's speech, the major difference being that the overlap between the teacher's speech and the child's internally produced speech will be greater than between written speech and the child's internally produced speech.

If the child is taught to associate the sounds in the teacher's dialect with the graphic symbols prior to his integrating these language sounds with his own, the discrepancy between the teacher's dialect and his own as internally represented on his coded array will cause a decrement in the amount of meaning which flows from the word once sounded. For the written word to evoke in him the full meaning the child has stored for it, the graphic word must be integrated with the neural pattern of the phonemes of the child's dialect not that of the teacher. Consequently, either the child need be taught to read in his own dialect using the phonemes of that language system or he must first tackle the additional integration problem of relating his dialect to the teacher's and then the teacher's dialect to the graphemes. The child whose teacher speaks the same dialect as his, does not face such a "language barrier".

The kind of disability which would result from dialect problems would be situational, limited to those instances where meaning is conveyed in the foreign dialect. Unfortunately, these situations frequently involve all of schooling for some children and hence the child's formal education becomes in jeopardy. While the child would appear imaginative and expressive at home and with peers, in the school setting he will appear dull, unexpressive, and bored. The failure of the teacher and subsequently of the graphic materials to access the child's imaginal processes will cause him to become uninterested and inattentive in school. Unless some integration training is adopted or the child has continued massive experience with the dialect spoken in his school so the integration of his language system with that of the teacher can occur, he will not be able to access his everyday experience and rich imaginal activity

using the teacher's dialect or graphic symbols. The child will continue to suffer within the school context by not having the spoken or written language activate the stored meanings and associations which constitute the richness of his experience.

Task Irrelevant Array Content.

The disabilities we have been considering involve structural or functional irregularities in the information processing and integrating system. Failure at educational tasks such as reading acquisition can also derive from two other sources, one involving interference from task-irrelevant content on the array, the second involving the processing complications resulting from anxiety.

Task-irrelevant content. The content issue was previously introduced when considering the information selection hierarchy. There the emphasis was on the "negative preference" for a given data source due to its inability to transmit information or stimulate further neural activity in either the motor or imaginal systems. Failure to entertain on one's informational array the data appropriate to educational tasks can also derive from competition by other content which within the educational context would be defined as task-irrelevant. It is certainly reasonable that within the educational situation, information is available to the child which has greater interest for him than does the educational task at hand. If the intrinsic value of working on the educational task is not as great as working on some other and if extrinsic rewards do not reverse this balance, the child will engage in the extra-school activity.

These extra-school activities can be many and diverse involving information from many different sources. Perhaps the most typical is drawing upon one's own mentation as an information source. Frequently given the pejorative name "day dreaming", this mental activity is likely more important to the child than the educational task at hand. One need explain without invoking invective constructs why he engages in such task-irrelevant behavior. Though it appears circular to claim that he prefers his own thought processes to the educational task at hand, the Information-Integration Theory predicts that the amount of mental activity stimulated by the channel he is processing is greater than that stimulated by the educational task. This empirical assertion can be validated or falsified: A most simple test would involve assessing the degree of distractibility as the child engages in reading versus "day dreaming". The Theory would predict that distracting the child from reading could be accomplished by a less intense signal than that required to distract him from day dreaming, indicating that the latter task more completely fills the array and stimulates post-array mental activity.

The breadth of information found to interfere with the educational task will depend on the interest with which the educational task is held. The child extremely bored by an educational task either because of one of the previously listed disabilities or perhaps because the material is being so poorly presented by the teacher, may turn to processing whatever "catches his eye". He need not remain passive but can create situations which will provide him with some opportunity for post-array stimulation, as for example, by passing notes, teasing, or otherwise interacting with other pupils.

The cases of competing content described thus far are occasioned by an extremely low preference for the educational material. Not all cases of competing content require that the educational task be held in such low esteem. Concerns at home such as his relationship with his parents or concern about his parents' relationship and, in general, the whole host of emotionally-laden conflicts to which children are susceptible can come to compete with the school task.

Besides the strictly educational tasks, the school provides a setting for the learning of a wide variety of developmental skills. These include working out peer relationships with the same and opposite sex, forming relationships with adults, evolving one's self concept, and expanding one's cognitive abilities. The importance of these problems in the child's life makes it seem inappropriate to refer to them as task-irrelevant. However, in the classroom situation, these concerns can all at times compete for array space with the information from the educational task at hand.

What is critical in determining whether "emotional problems" of the child will interfere with schoolwork is their degree of trans-situationality; a pervasive problem will be cued by a wide variety of events and consequently often gain entrance onto the informational array. Because emotional problems frequently have an associated bodily state such as increased muscular tension, gastro-intestinal distress, elevated heart rate, and the like, these states can come to stimulate the cognitive component of the problem. The cues from these bodily states are costly of array space to process and costly of energy to inhibit. As the bodily state is a part of the child, these cues are maximally trans-situational, constantly reminding the child of his problems. The child's concerns are typically not so easily scheduled as are the classes in a school day. When seated in his reading group, the child may be more concerned about his peer status than about the content of his beginning reader. The fact is that the teacher must compete for the child's attention, i.e., for space on his informational array. To be at all successful requires open access to the child's informational array attained by providing him with activities which stimulate his imaginal system.

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